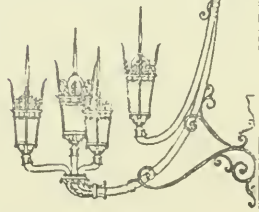


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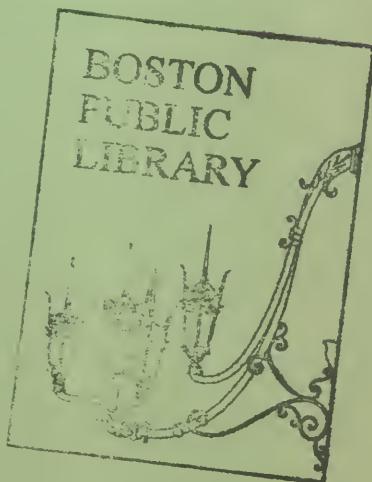
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**E N G I N E E R S**

Back Bay  
M 213



ENGINEERING REPORT  
ON  
UTILITY SYSTEMS  
FOR  
BOSTON REDEVELOPMENT AUTHORITY  
IN  
BACK BAY GNRP AREA

PROJECT NO. MASS. R-47



CHARLES A. MAGUIRE & ASSOCIATES  
Engineers

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LIST OF EXHIBITS

<u>Exhibit</u>	<u>Title</u>
47-1*	Sewer and Storm Drain System
47-2*	Water Distribution System
47-3*	Police Signal System, Fire Alarm System, and MTA Facilities
47-4	Typical Sections - Existing Sewers
47-5	Typical Sections - Existing Sewers
47-6	Main Interceptors, Points of Pollution, and Tributary Areas
47-7	Water Systems Data, Fire Flows, Main Failures, and Major Supply Mains
47-8	Schematic Location of Major MTA Facilities

\* These exhibits, consisting one map each, are not bound into the Interim Report but are included as a separate enclosure



## SUMMARY

### OBJECTIVES

The objectives of the Engineering Services and the purposes of this report are to provide an inventory of existing publicly owned utility systems and to comment on the existing systems in the Back Bay GMRP Area. The utilities covered are the main components of the sewer and storm drain systems, the water system, the police and fire communication systems and the MTA facilities.

This Interim Report does not include the Proposed Planning and Future Land Use of the Authority or any analysis of the systems with regard to this Planning.

### INVENTORY

The inventory phase of this report has involved the gathering and assembly of all reasonably available data concerning these systems and the notation of this data on plans of the area. This report covers approximately 20 miles of sewers and storm drains and approximately 5 miles of water lines. In most cases the size, shape, material, year of installation, ownership, slope of conduit and capacity of conduit flowing full have been shown for the sewer and storm drain systems. Similar applicable information has been indicated for the water lines, the police and fire communication lines and the MTA facilities.

### ANALYSIS

Commentary on the existing system is based on a limited analysis conducted in order to point out and evaluate any deficiencies that presently exist in the sewerage and water distribution systems.



## SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Conclusions and Recommendations resulting from the studies as outlined on the previous page for the Back Bay GNRP Area are summarized as follows:

### Sewer and Storm Drain System

Conclusions: a. Approximately 30 to 40 percent of the Back Bay GNRP Area is served by a separate sanitary sewerage system.

b. Combined sewers serve the remainder of the Area and discharge low flows to the West Side Interceptor and overflows to the Boston Marginal Conduit.

c. Recent surcharging in the West Side Interceptor is attributed to infiltration through the conduit, entrance of tidewater through faulty tide gates in other parts of the system, and the inability of the Calf Pasture Pumping Facilities to handle the discharge. Completion of the Metropolitan District Commission Plan will eliminate the need for the Calf Pasture Pumping Facilities.

d. The Metropolitan District Commission Sewerage Plan will provide relief of the West Side Interceptor by diversion of flow to the Boston Main Drainage Relief Sewer.

e. The main combined sewers are generally adequate for storm frequencies of from 10 to 25 years.

f. Flow measurements at selected points throughout the systems are necessary to serve as a sound basis for hydraulic analysis of flows to evaluate the adequacy of individual conduits.



g. Details of overflow structures and sewer conduits are not available in several locations where this data is necessary for analysis of the systems.

h. Overflow from the local combined systems to the Boston Marginal Conduit may be frequent as a result of the surcharged condition of the West Side Interceptor.

i. Previous studies indicate that the Boston Marginal Conduit overflows to the Charles River Basin approximately one day in every ten days, or approximately one quarter of all days of rain.

j. The overflows from the Boston Marginal Conduit are definite sources of pollution to the Charles River Basin.

k. The operation of the MDC Sewerage System will significantly reduce the frequency of overflow to the Marginal Conduit, thereby reducing pollution in both the Charles River Basin and the tidal estuary.

l. Construction of the proposed Boston Marginal Conduit Pumping Station by the MDC will significantly reduce the frequency of overflow and resultant pollution to the Charles River Basin, as well as surcharging in the local combined systems.

m. The Charles River Basin Elevation Control Project will prevent a re-occurrence of flooding of the low areas as resulted from storms in 1954 and 1955.

n. None of the regulator chambers in the Back Bay GNRP Area contain regulators.



o. The physical condition of the conduits, most of which are about 50 to 90 years old, is essentially unknown.

p. Provision of separate systems throughout the Back Bay Area would result in the near elimination of overflows of sewage to receiving waters, and increase the effective capacity of the West Side Interceptor. The cost of providing this separation exclusive of costs of reconstruction or repair of existing conduits due to poor condition or inadequacy will range from 2.5 to 3.0 million dollars.

Recommendations: a. Undertake a program of sewage flow gaugings and storm flow observations at selected points in the systems to provide a determination of typical dry weather flows and storm flow conditions for present land use.

b. Undertake a field inspection survey of the physical condition of selected sewer and storm drain conduits. Special emphasis should be placed on major conduits, and the systems in those areas planned for redevelopment, extensive rehabilitation, or where either will cause an extensive change in land use patterns. Condition data from surveys in other GNRPA Areas should be evaluated as an aid in this program.

c. Provide for a field determination of unrecorded details of selected conduits and structures, as necessary, for analysis of the systems.

d. Provide for inspection of regulator chambers to consider the need for replacement of regulators or repair or reconstruction of the chambers as required, consonant with the final plan for modification of the systems.



e. Provide separate systems for sanitary sewage and storm flow to the maximum extent practicable, depending upon: future land use planning, the extent of reconstruction of streets, condition of existing sewers, the extent of other utility work required in the area, and the extent to which separation of existing building drainage is effected under the rehabilitation program.

f. Initiate an overall study of the Boston Main Drainage System to determine the combined effect that the operation of the MDC System and the Urban Renewal Program will have upon flows.

#### Water Systems

Conclusions: a. The Metropolitan District Commission supply mains are considered to be fully adequate in capacity to satisfy present demands.

b. The existing system in the Back Bay Area appears to be generally sound structurally, and adequate in capacity for present demands; however, some apparent deficiencies in the various components of the system are listed hereafter:

1. Considerable tuberculation exists in the smaller distribution mains and to a lesser extent in the larger sized distribution and supply mains.
2. There is a high incidence of main failures, in Boylston Street and Huntington Avenue.
3. The condition of the 40 inch low service main in Beacon Street is questionable due to its age.



4. The 16 inch low service main in Exeter Street, the 24 inch low service main in Massachusetts Avenue, and the 20 inch high service main in Huntington Avenue, may be approaching their capacity limits.

5. Maintenance of high service pressure and supply to City Proper is highly dependent upon the 42 inch high service main in Huntington Avenue and Newbury Street.

c. Main failure records indicate that mains 16 inches and larger, and mains laid after 1930, are structurally sound, and that the frequency of failure is greater in the high pressure service than in the low pressure service.

d. Metropolitan District Commission water has a relatively high degree of corrosiveness.

e. Unlined cast iron mains in the Boston System may have a shorter useful life than is indicated by the Hazen-Williams predicted average trends.

f. The results of field tests to be conducted in the South End Project Area, and inspection of mains exposed during construction of the Massachusetts Turnpike, together with studies of other available data in all GNRP Areas will provide data for re-evaluation from which additional conclusions may be drawn regarding adequacy and condition of the system.

g. Additional fire flow tests are necessary to accurately determine the fire protection available in areas served by the high service system and portions of the low service system.



Recommendations: a. Request the National Board of Fire Underwriters to undertake studies, and report on the fire protection facilities of the City as a whole.

b. Consider for adoption, "that a complete study be made of the arterial system and of the deterioration in carrying capacity, including minor distributors," as recommended and deemed of "most importance" by the National Board of Fire Underwriters in their report of 1951.

c. In conjunction with the above recommendation, consider initiation of a comprehensive program of analysis of the hydraulics of the systems through the use of a modern engineering technique, such as the McIlroy Analysis. This program would provide the Authority with sound engineering data to serve as a basis for optimum, economical modification of the supply and distribution mains as necessitated by the Redevelopment Program. In addition, it could become a continuing program that could ultimately be adopted by the City with highly beneficial short and long range results, including major economies which have been proven in comparable cities in recent years.

d. Consider a field inspection of portions of those mains to be exposed during the construction of the Massachusetts Turnpike Extension. The results of this program could provide sound data to serve as a basis for determining the physical condition of these and other mains in the Boston System.



e. Consider replacing or cleaning and lining every main over twelve inches in diameter installed before 1900, especially those located in streets to be reconstructed. The final decision should be based upon a field inspection of a portion of the main, where possible, coupled with hydraulic tests, to determine its physical condition and hydraulic capacities.

f. Evaluate for future adequacy, City of Boston transmission mains in the Back Bay Area by an overall study of the arterial system when more detailed planning for other GMRP Areas is available.

#### Police Signal System

Conclusions: a. Principals of the Signal Service Division consider the Police Signal System to be adequate in that it accomplishes the purposes for which it was designed.

b. There are no plans available at present proposing modification of the existing system.

c. It should be noted that this Interim Report does not reflect any effect on the Police Signal Service of the conclusions and/or recommendations from the recently released so-called "Quinn-Tamm Report" on the Boston Police Department.

Recommendations: When advanced planning is available, the Authority, in conjunction with the Director of Signal Service, should consider the feasibility of modifications of the system consonant with the objectives of the Signal Service and the Boston Development Program.



### Fire Alarm System

Conclusions: a. Principals of the Fire Alarm Division consider the fire alarm system to be adequate for present requirements.

b. The Fire Alarm Division proposes no modifications to its system at this time.

Recommendations: a. When advanced planning is available it is recommended that the Authority, in conjunction with the Fire Alarm Division of the Boston Fire Department, consider modification of the system consonant with the objectives of the Fire Department and the Boston Development Program.

b. Give primary consideration to that policy of the Fire Alarm Division which requires that revisions or relocations of box circuits or alarm circuits be complete and operating correctly before existing circuits are taken out of service.

### MTA Facilities

Conclusions: a. Buses are the only form of MTA surface transit in use in this area.

b. Extensive changes to the MTA system must be anticipated in the next few years.

Recommendations: a. Consider removal of abandoned facilities in redevelopment areas.

b. Consider special emphasis on existing facilities in connection with the Redevelopment Program.

c. Consider contemplated studies of the Mass Transportation Commission and the MTA in urban renewal planning.



## INTRODUCTION

### OBJECTIVES

The Boston Redevelopment Authority, as the administering agency for the Boston Development Program, has undertaken many phases of activity in connection with the planning, development and direction of the program. One of the initial stages of development, called General Neighborhood Renewal Plan (GNRP), involves, in part, preliminary engineering studies of the utility systems. It is at this level of study that this Interim Report, which covers the area designated as Back Bay R-47, is concerned.

The objectives of the Engineering Services and the purposes of the Report are to provide an inventory of the existing utility systems (namely: water, sewer and storm drain, police and fire communications and Metropolitan Transit Authority (MTA) facilities) and to comment on the existing systems. This Interim Report does not include the Proposed Planning and Future Land Use of the Authority or any analysis thereof.

The use of this Interim Report and the analyses contained herein are of a supplemental nature. The user must understand that the data and analyses are indicative of the conditions existing in the Back Bay GNRP Area at the time of study of the systems, based only on available information. The Conclusions and Recommendations in this Interim Report are based on these analyses.

Interim Reports have been submitted for the Downtown, Parker Hill-Fenway, and Roxbury-North Dorchester GNRP Areas, and the South End Project Area. Reports upon the South Boston, Jamaica Plain, and East Boston GNRP Areas will be forthcoming. Subsequent study and analyses in these reports



may require a modification of the Conclusions and Recommendations of previous reports.

The Final Report, to be assembled in mid 1963, will consider all areas individually and collectively. It will incorporate the modifications to the Conclusions and Recommendations in the Interim Reports resulting from a review of the interactions of the systems in the areas covered by the several Interim Reports.

#### INVENTORY OF SYSTEMS

The inventory of the several systems mentioned in the preceding section has been indicated on a separate set of 3 drawings prepared expressly for this purpose.

These exhibits, consisting of one map each, are indicated as Exhibits 47-1, 47-2, and 47-3 and are an integral part of this report; however, due to their size, they have not been bound into the Report.

#### ANALYSIS OF SYSTEMS

The analyses of the several systems mentioned previously has been carried out in a manner designed to point out any deficiencies which may exist in the present systems. In addition the analyses have, in several cases, uncovered areas where, from an engineering viewpoint, it is considered that improvements to the system could be worthy of consideration for either present action or future study under more advanced programs. It is on these analyses that the Conclusions and Recommendations in this Interim Report are based.



In an effort to provide a budgetary yardstick for the Authority in development of the Back Bay GMRP Program, estimates have been made, on the basis of past experience in the engineering field, of the costs involved for correcting various deficiencies and/or making various improvements. Specifically, this has been done wherever the analysis of the existing system has indicated that a possible deficiency in the particular system may exist, or where an improvement appears to be warranted.



## SEWER AND STORM DRAIN SYSTEMS

### DEVELOPMENT OF THE BOSTON SEWER SYSTEM

Boston was settled in 1630, and its Sewer System is reported to have originated prior to 1700. The present system can best be understood from an outline of the history of its development, since this system is the result of successive adaptations of and additions to the old sewers as conditions have changed and as the governing bodies of the City alleviated the nuisances and health hazards which they encountered.

The first sewers were surface drains built by private individuals. Some consisted of a wood bottom, brick sides and a flat stone cover; others had a brick invert and a flat stone covering; still others were constructed entirely of wood. In general all these drains connected directly to tide water.

In the early 1820's the City assumed control of all existing sewers and the construction and maintenance of new ones. Policies and controls changed constantly. It was mandatory by 1877 that all sewage be discharged into the sewers. Thus, the original surface water drains were changed into common sewers of the "combined" type. The outlets for these combined sewers were scattered around the harbor front and tide water areas. This resulted in complaints of nuisances from polluted flats.

These nuisances increased yearly, and in 1875 a commission was appointed to devise a remedy. This commission advised that an intercepting system of sewers should be built encircling the City at the waterfront and discharging at Moon Island. With minor exceptions and slight modification,



this plan was adopted and eventually resulted in the establishment of the West Side Interceptor, the East Side Interceptor, the Boston Main Interceptor, the South Boston Interceptor, the Dorchester Interceptor, the Calf Pasture Pumping Station, and the Moon Island Facilities which still serve the Boston Sewer System.

#### METROPOLITAN SYSTEMS

Even before the completion of the Boston System, unsanitary conditions in the surrounding cities and towns of the Metropolitan District prompted the State Legislature of 1889 to take action. This action resulted in a report which recommended the building of the North Metropolitan System, and the Charles River Valley System. These were built in the 1890's, and subsequently the Legislature provided for the building of the Neponset Valley System, by taking over the two sections of the Dorchester Interceptor and providing for construction of the balance of the system.

The North Metropolitan System still serves the cities and towns in the Mystic Valley and the municipalities north of Boston, such as Chelsea, Everett, etc. It also receives the sewage of Charlestown and East Boston, but has no other connection with the Boston Sewer System.

The systems in the Charles and Neponset River Valleys were built as extensions of the Boston intercepting system and operated as such until detached and connected with the Metropolitan High Level Sewer, which was built to serve the high lands of the cities and towns in the Charles and Neponset Valleys, as well as those of Boston. The flows of the Charles and Neponset intercepting sewers were diverted from the City's System and connected to the High Level Sewer with an outlet for the system at Nut Island. This established the South Metropolitan Sewer System.



The establishment of the South Metropolitan System in conjunction with the North Metropolitan System and the Boston Sewer System, later known as the Boston Main Drainage District, resulted in three large sewer outlets into Boston Harbor at Nut Island, Deer Island and Moon Island, respectively.

The Metropolitan High Level Sewer, having been designed to take the dry weather flow only, with a small addition of storm water, implied the building of separate systems and the conversion of existing combined systems to the separate principle. This work and the building of the large storm water conduits in the brook valleys constituted the beginning of a separate system which was confined, primarily, to the outlying areas of the City. These storm flow conduits have generally followed the line of the old water-courses. The larger and more important of these are the Stony Brook Conduit and the Fenway Foul Flow Channels.

#### METROPOLITAN DISTRICT COMMISSION PLAN

From the brief outline of the history of the systems of sewers and storm drains in Boston and the adjoining areas, it can be seen that prior to 1900 there was concern for the nuisances created by the discharge of sewage. In the next fifty to sixty years this concern did not decrease and the discharge of untreated sewage and combined storm water and sewage into Boston Harbor became the subject of a number of reports. These resulted in the establishment of the Metropolitan District Commission with its program for alleviation of and treatment of the pollution of the rivers



and harbors in the Metropolitan Area. The many reports, studies by special commissions and legislative authorizations were climaxed in 1951 in a report to the Metropolitan District Commission by Charles A. Maguire & Associates on "A Proposed Plan of Sewerage and Sewage Disposal for the Boston Metropolitan Area."

The plan, authorized by Chapter 645 of the Acts of 1951, will eliminate all sewage discharges at Moon Island, and will provide for all of the sewage from the North Metropolitan District, the Boston Main Drainage District and the South Charles portion of the South Metropolitan District to be conducted to Deer Island for treatment. With the completion of this plan, there will be no discharge of untreated sewage to the harbor, except overflows of sewage diluted with water. The overflows originating in the Back Bay GMRP Area are discussed later in this report under the section entitled "Overflows and Pollution."

The sewage treatment facilities at Deer Island and the new conduit system authorized by the above Act, are presently in various stages of completion and/or construction. The ultimate diversion of all sewage from the Boston Main Drainage District through proposed headworks at Ward Street or Columbus Park and the tunnel system to Deer Island will result in beneficial effects to the City of Boston in approximately five years. The MDC Sewerage Plan and its overall effect on those sewers pertinent to the Boston Redevelopment Program will be discussed in greater detail in the final report.



#### Metropolitan District Commission Sewerage Plan in the Back Bay GNRP Area

None of the components of the MDC sewerage plan are in the Back Bay GNRP Area. The operation of the MDC system will relieve flow in the West Side Interceptor, however. The Boston Main Drainage Relief Sewer will create a draw-down of the water surface of the Boston Main and the West Side Interceptors, thus reducing the frequency of overflows from the West Side Interceptor and its tributary combined sewers to the Boston Marginal Conduit. Therefore, the frequency of overflow and the pollution to the Charles River Basin will be reduced, as well as the pollution to the tidal water below the Charles River Dam.

#### The Charles River Basin Elevation Control Project

The project consists of a pumping station and a new dam to replace the existing Charles River Dam. It is intended that the pumping station will control the basin elevation and prevent the re-occurrence of flooding of the low areas as resulted from hurricane storms in 1954 and 1955. The dam portion of this project will be constructed in the vicinity of the abandoned Warren Avenue Bridge, thus converting a reach of the tidal estuary to fresh water as a part of the Charles River Basin. The Charles River Basin Elevation Control Project is in the process of being designed.

#### The Proposed Boston Marginal Conduit Pumping Station

The Boston Marginal Conduit, a part of the Metropolitan District Commission's System, receives overflows from the sewers tributary to the West Side Interceptor and discharges to the tidal estuary downstream of the Charles River Dam. The



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conduit has a limited capacity and can only discharge when tidal conditions permit. As a result, the Marginal Conduit frequently overflows to the Charles River Basin. The Metropolitan District Commission has undertaken studies to construct a pumping station at the downstream terminus of the Marginal Conduit to relieve the conduit and reduce the frequency of overflows and pollution to the Charles River Basin.

#### ANALYSIS OF EXISTING SYSTEMS

##### General

The Back Bay Area is bounded by Back Street on the north; the New York, New Haven and Hartford Railroad, Clarendon and Stuart Streets on the south; Arlington Street on the east; and Massachusetts Avenue on the west.

It comprises about 350 acres and has a population of about 20,000 persons. Approximately 30 to 40 percent of the area is served by separate systems as a result of legislative acts encouraging and, in some instances, requiring the construction of separate systems in areas tributary to the Charles River Basin. The remainder of the Back Bay is served by combined systems.

The dry weather flow of the sanitary sewers and the local combined sewers in the Back Bay discharge to the West Side Interceptor. Storm flows from the local systems discharge through overflows to the Boston Marginal Conduit which, in turn, discharges to the tidal estuary downstream of the Charles River Dam, and when its capacity is exceeded, overflows to the Charles River Basin



### Sanitary Sewerage System

The main sanitary sewers in the Back Bay Area are located in Dartmouth Street, St. James Street, Boylston Street, and Back Street, as shown on Exhibit 47-6.

The sanitary sewer in Dartmouth Street varies in size from 2'6" in diameter to 3'0" in diameter and in capacity from 5.0 to 7.0 mgd. It starts at Boylston Street and flows north along Dartmouth Street until it discharges to the West Side Interceptor at Beacon Street. This conduit serves the area adjacent to Dartmouth Street, comprising a total of about 85 acres.

The main sanitary sewer for the Back Bay Area begins in the Downtown GNRP Area serving a portion of the Park Square section. It enters this Area at St. James Avenue and Arlington Street, runs along St. James Avenue, Dartmouth Street and Boylston Street, and discharges to the West Side Interceptor at Hereford Street. This sewer varies in size from 22" in diameter to 2'9"x3'3" and in capacity from 2.6 mgd to 9.5 mgd. The area served by this sewer comprises about 65 acres.

The sanitary sewer in Back Street is an 18" conduit serving the area between Beacon and Back Streets. It discharges its flows to the West Side Interceptor through 12" conduits in Clarendon and Hereford Streets. The total area served by this conduit comprises about 22 acres.

### Storm Drainage Systems

The storm drains serve essentially the same area as the sanitary sewers. In most instances, the storm drains have either been constructed parallel to or on top of the existing sanitary sewers and are shown on Exhibit 47-6. The storm drains do not have separate outlets, but discharge through the main combined sewers to outlets in the Boston Marginal Conduit.



The major storm drains serving the area of separate systems lies in St. James Avenue and Blagden Street. These conduits have been constructed in combination with the sanitary sewer in those streets, with the storm drains above the sanitary sewers. The storm drains in this area have two outlets, one to the combined sewer in Berkeley Street and the other to the combined sewer in Dartmouth Street.

The storm drain discharging to the 6'0"x6'6" combined sewer in Berkeley Street begins in the Downtown GNR<sup>D</sup> Area near Park Square. It enters the Back Bay at Arlington Street and extends along St. James Avenue to Berkeley Street where it discharges to the above-mentioned combined sewers. The size varies from 12" to 30" in diameter. The total area served comprises about 16 acres.

The storm drain discharging to the 6'0" combined sewer in Dartmouth Street begins at St. James Avenue and Berkeley Street and runs westerly along St. James Avenue to Dartmouth Street where it discharges to the above-mentioned combined sewer. This conduit varies in size from 15" to 3'6"x3'6", in capacity from 1.5 mgd to 13.0 mgd, and serves a total area of about 31 acres.

#### Combined Sewerage Systems

There are four main combined sewers in the Back Bay Area serving almost the entire drainage area. These conduits are tributary to the West Side Interceptor and the Boston Marginal Conduit. The four main combined sewers are described as follows:



1. The combined sewer in Berkeley Street varies in dimension from 36"x36" to 6'0"x6'6" and in capacity from 10 mgd to 120 mgd. It discharges dry weather flow to the West Side Interceptor through a regulator at Beacon Street, and storm flow to the Boston Marginal Conduit. This sewer drains the area between Clarendon Street, Stuart Street, Arlington Street and Storrow Drive, comprising a total of about 60 acres.
2. The combined sewer in Dartmouth Street varies in dimension from 4'0"x4'2" to 6'0" and in capacity from 16 mgd to 150 mgd. It begins in Huntington Avenue, extends along Dartmouth Street, and discharges dry weather flow to the West Side Interceptor through a regulator chamber at Beacon Street. Storm flow is discharged to the Boston Marginal Conduit. This sewer drains the area between Clarendon Street, Huntington Avenue, Dartmouth Street, Boylston Street and Back Street, as well as the area tributary to the storm drain in St. James Avenue. The total area served by this conduit is approximately 81 acres.
3. The 24"x31" combined sewer in Garrison Street has a capacity of 5.5 mgd. It carries the flow from the 2'x3' combined sewer in St. Botolph Street. At Huntington Avenue, in order to cross the Prudential Center site, this sewer has recently been constructed as an inverted siphon composed of twin 30" reinforced



concrete pipes encased in concrete. The siphon changes in section to twin 36" cast iron pipes at Boylston Street and connects to a 5'0"x6'0" combined sewer running along Fairfield Street. This conduit drains the Prudential Center site, the area bounded by Huntington Avenue, Irvington Street, the New York, New Haven & Hartford Railroad, and West Newton Street, and the area bounded by Boylston Street, Gloucester Street, Storrow Drive, and Exeter Street, a total of 95 acres. Dry weather flow discharges to the West Side Interceptor through a regulator chamber at Beacon Street and storm flow to the Boston Marginal Conduit.

4. The combined sewer in Hereford Street begins on Cumberland Street just south of St. Botolph Street, runs along Cumberland Street, Huntington Avenue, Norway Street, Salton Street, and Hereford Street to Beacon Street where it discharges dry weather flow to the West Side Interceptor and storm flow to the Boston Marginal Conduit. It drains the area bounded by Gloucester Street, the Prudential Center, West Newton Street, the boundary of the Back Bay GNRP Area, and in addition drains a portion of the Parker Hill-Fenway GNRP Area, west of Hereford Street. This sewer varies in size from 24"x31" to 8'0"x8'6" and in capacity from 6 mgd to 250 mgd. The area drained by this conduit comprises about 85 acres in the Back Bay GNRP Area and 31 acres in the Parker Hill-Fenway GNRP Area.



### West Side Interceptor

The major interceptor of the Boston Main Drainage System in the Back Bay GNRP Area is the West Side Interceptor. The entire sewerage system in this Area is tributary to this conduit. It begins in the Downtown North GNRP Area near Commercial and Prince Streets. It enters the Back Bay Area at Beacon and Arlington Streets, extends westerly along Beacon Street, turns south along Hereford and Falmouth Streets and leaves the Area at Falmouth Street and Massachusetts Avenue. The total area tributary to the West Side Interceptor encompasses the entire Back Bay GNRP Area and portions of the Downtown North and the Parker Hill-Fenway GNRP Areas.

In the Back Bay Area, the West Side Interceptor has a 4'9"x5'6" horse-shoe shaped cross section, is laid on a uniform slope of .0005 ft/ft and has a capacity flowing full of 33 mgd. This conduit receives the low flow from the combined systems and the sewage flow from the sanitary systems in the Back Bay Area. This flow is discharged to the Boston Main Interceptor which, in turn, discharges to the Calf Pasture Pumping facilities in South Boston.

### The Boston Marginal Conduit (MDC)

The West Side Interceptor receives flows from a highly developed area of the City of Boston, served almost entirely by combined sewers. The original design of the West Side Interceptor provided for very limited interception of storm flow and was based upon the use of closely spaced, regulator controlled, overflows discharging directly to the Charles River estuary. The Charles



River at that time was tidal to the Watertown Dam. Maintaining the Charles River Basin level at elevation 8.0 created a substantial backwater on these overflows. Moreover, the discharge of mixed sewage and storm flow to the Basin during storms also created objectionable conditions. The Boston Marginal Conduit was accordingly designed and constructed.

The Boston Marginal Conduit has its origin in the Parker Hill-Fenway GMRP Area in the Fens gatehouse at the termini of the Old Stony Brook Conduit and the Commissioners' Channel. It enters the Back Bay Area at the Harvard Bridge and Storrow Drive, runs east along Storrow Drive and leaves the Area at Arlington Street. The conduit enters the Back Bay Area as a 6'4"x7'8" horseshoe section. At Dartmouth Street and Storrow Drive, it changes to an 8' diameter section. The conduit receives the storm overflow from the combined sewers tributary to the West Side Interceptor and the low flow from the Foul Flow Channels of the Stony Brook, in addition to the overflows caused by surcharging of the West Side Interceptor.

The capacity of the conduit is limited due to the fact that it has been laid flat with its invert at elevation -1.5 and is dependent on the tide for gravity discharge to the tidal estuary downstream of the Charles River Dam. When the capacity of the conduit is exceeded or when it cannot outlet due to tide conditions, the Marginal Conduit overflows to the Charles River Basin. The overflows from the Marginal Conduit are discussed later in the section entitled "Overflows and Pollution."



The main function of the Boston Marginal Conduit is to afford relief of the sewers tributary to the West Side Interceptor and to limit pollution to the Charles River Basin by discharging to the tidal estuary below the dam.

During storms, and as soon as the rainfall, plus the sanitary flow, exceeds the limited capacity of the West Side Interceptor, excess flow overflows to the Boston Marginal Conduit. Due to its limited capacity, the Marginal Conduit overflows to the Charles River Basin frequently. This condition is aggravated by the introduction of flow from the Stony Brook System at the upper terminus of the Conduit. Studies included in the "Report upon Boston Marginal Conduit Pumping Station, Project 13" to the MDC, in 1958, indicate that overflows from the Marginal Conduit to the Basin occur one day in every ten days, and the discharge from the conduit is precluded by the tide 22 percent of the time. The conduit has a flowing capacity of 140 mgd, 5 percent of the time, and a capacity of 73 mgd, 50 percent of the time, based on the assumptions of (1) a gravity conduit with no basin overflow, (2) no flow from Stony Brook Systems, and (3) flow from drainage areas intercepted in proportion to tributary areas at each inlet.

Even before the Marginal Conduit was completed, the probable necessity for a pumping station was recognized. However, it was not provided for until the legislature enacted the Metropolitan District Commission's overall plan in 1951. In 1958, a report "Boston Marginal Conduit Pumping Station, Project 13" was submitted to the Commission. At present, the pumping station is still one of the Metropolitan District Commission's future projects.



Pumping will provide the Marginal Conduit with a continuous outlet to the tidal estuary below the Charles River Dam and will afford relief to the tributary sewers in the Back Bay by reducing surcharging and flooding in the critically low areas adjacent to the Charles River Basin.

#### Capacities and Flows

The dry weather flows from the main combined sewers tabulated hereafter have been estimated using a summary of water records of the City of Boston for the various wards in the Back Bay GNRP Area, and an assumed value for ground water infiltration into the system. The figures obtained using the water records and assumed infiltration values are only intended to give an indication of the probable range of average dry weather flows.

Flows in Separate and Combined Sewers: Estimates of dry weather flows contributed by the Back Bay GNRP Area indicate that a total of approximately 4.3 mgd flows to the West Side Interceptor, of which 3.3 mgd is sanitary flow and 1.0 mgd is infiltration.

The following tabulation on "Estimated Sewage Flows for Major Sewer Conduits," indicates the size and capacity of the major conduits, the connections to the Boston Main Drainage System and the overflows to the Boston Marginal Conduit, as well as estimates for average dry weather flow. The tabulation has been compiled from available recorded information. A review of the tabulation indicates that the average dry weather flow in the combined systems is small, in the range of 1 percent to 5 percent of the flowing full capacity of the conduits. The capacity of the West Side Interceptor is such that it provides for the peak dry weather flow, plus an equal quantity of storm flow.



An evaluation of adequacy of capacity of the combined sewers is based upon storm flows because the dry weather flows require such a small percentage of the total capacity. Accepted practice for main storm drains is to provide capacities adequate for a 5 to 10 year storm frequency as a desirable condition, and for a 2 to 5 year frequency as a minimum condition in areas of this type.

The flowing full capacity of the several main conduits in this Area indicate that they are generally adequate for storms of 10 to 25 year frequency.

Flow in the West Side Interceptor: The West Side Interceptor has a capacity of about 33 mgd. It carries the flow from the combined sewer systems in the Downtown North GNRP Area, the Parker Hill-Fenway GNRP Area, and the Back Bay GNRP Area. Although sewer gaugings from the "Report on Sewerage and Sewage Disposal," by Charles A. Maguire and Associates in 1951, indicate that the West Side Interceptor contributed an average dry weather flow of about 13.0 mgd to the Main Drainage System at that time, interviews with personnel of the Sewer Division indicate that this conduit is now surcharged a majority of the time. This condition is attributed to increasing entrance of ground and tide water into the systems and the inability of the pumping units at Calf Pasture to handle the discharge due to their frequent need of repair.

Before final conclusions can be drawn regarding the adequacy of these conduits, a program of gaugings and field observation should be undertaken at selected locations in the system to provide a determination of typical



dry weather flows, storm flow and overflow conditions. An analysis of individual sewers, if performed at this time, would involve assumptions regarding flows in the systems. For the analysis to be meaningful, these assumptions should be verified by field observations and gaugings. With observed flow data, the individual sewers and storm drains can be evaluated regarding adequacy of capacity on a sound engineering basis. Therefore, a detailed analysis of individual sewers, preceding the collection of flow data, is not considered to be in the best interests of the Authority.

Bases for Capacity Computations: The flowing full capacities of sewers and storm drains 24 inches and greater in size, shown in the following tabulations and indicated on Exhibit 47-1, have been computed for conduits flowing full using the Manning and Kutter formulae where sufficient recorded data was readily available. Each of these formulae involves three variables: the slope or gradient of the sewer, the hydraulic radius, which is a function of the size and shape, and a roughness coefficient of "n" value.

The hydraulic radius has been determined on the basis of size and shape as noted on the following drawings. Where exact shapes were not readily available, an assumption has been made on the basis of an evaluation of known construction in the same area and of approximately the same age. Exhibits 47-4 and 47-5 give the dimensions and proportions for typical sewer shapes of the majority of the sewers encountered in the Back Bay GMRP Area. The basic shapes are circular, egg, ovoid, horseshoe and U-shape. It has been determined that variations from these shapes could be equated to a basic



shape of equivalent area and still achieve an accuracy of 5 percent which is well within the accuracy limitations for capacity computations based on the assumed values of the coefficient of roughness.

The coefficients of roughness or "n" values are in accord with accepted practice in the field, based on engineering judgment and using an average value for each type of conduit considered. The values used are as follows:

<u>Type</u>	<u>"n"</u>
Wood	.013
Concrete (since 1950)	.013
Cast Iron or Iron	.015
Vitrified Clay	.015
Brick (since 1950)	.015
Concrete (pre-1950)	.015
Brick and Wood	.015
Material Unknown	.015
Brick (pre-1950)	.017

The slopes of all sewers have been determined from the available invert elevations and from scaled distances between manholes as taken from Exhibit 47-1.



# ESTIMATED FLOWS FOR MAJOR CONDUITS

Intercepting Sewer and Location of Connection to Tributary Sewers (1)	Size	Capacity Flowing Full (mgd)	Avg. Dry Weather Flow (mgd)	Remarks
<u>Intercepting Sewer</u> West Side Interceptor	4'9" x5'6"	33	13.0(2)	
<u>Combined Sewers (3)</u> Berkeley St. @ Beacon St. Dartmouth St. @ Beacon St. Fairfield St. @ Beacon St. Hereford St. @ Beacon St.	6'0" x6'6" 6'0" 6'0" x6'6" 6'0" x6'6"	68 40 N.A. (4) 57	0.6 0.2 1.1 0.9(5)	Overflows through 4'0" x5'0" Overflows through 3'0" x4'0" Overflows through 3'0" x4'0" Overflows through 4'3" x4'3"
<u>Sanitary Sewers</u> Back St. @ Beacon St.	18"			Discharges to West Side Interceptor through 12" connections at Clarendon and Hereford Streets.
Dartmouth @ Deacon St. Boylston St. @ Hereford St.	3'0" 2'9" x3'0"	7.0 9.5	0.5 1.4	
<u>Storm Drains</u> St. James Ave. @ Berkeley St. St. James Ave. @ Dartmouth St.	30" 3'6" x3'6"	N.A. 13.0		Discharges to Berkeley St. combined sewer Discharges to Dartmouth St. combined sewer
(1) All sewers are combined, except as noted.				
(2) Includes 4.3 mgd contributed by the Back Bay Area and 0.4 mgd by the Parker Hill-Fenway Area through Hereford sewer.				
(3) Combined sewers discharge low flows to the West Side Interceptor and overflows to the Boston Marginal Conduit.				
(4) Information not available.				
(5) Includes 0.4 mgd contributed by Parker Hill-Fenway Area through 30" x36" sewer in Beacon Street.				



### Condition

Data available from records, and interviews with personnel responsible for maintenance have indicated that very little is known regarding the physical condition of the existing sewerage and storm drainage systems in the Back Bay GMRP Area. Such information as it was possible to interpret has been indicated herein in a general manner. However, specific indications of condition for each run of conduit are not available.

The majority of the sewers and storm drains in the Back Bay Area are constructed of brick, concrete or vitrified clay. Most of the brick sewers and storm drains were laid in the late 1800's or early 1900's, and few major repairs have been made since their installation. Due to the danger in entering a sewer for visual inspection of the inside of the conduits, coupled with the fact that few extensive structural failures have occurred, very little is known about the physical condition of the sewerage system.

Two serious failures have occurred recently on the Boston Main Interceptor in Dorchester and South Boston. The causes of failure are being studied by the Sewer Division and will be available at a later date. These failures serve to emphasize the fact that the condition of the conduits is an unknown factor and that serious unpredictable failures may occur. Repair of a major conduit can be very expensive and time consuming and cause serious disruption of traffic, as well as requiring emergency diversions of sewage flows that can seriously increase pollution of receiving waters. As an example, the collapse of the Main Interceptor on Massachusetts Avenue, near Clapp Street, has required the following:



1. Diversion of major flows necessary to accomplish repairs consisted of the following:

- a. All flows from the East Side Interceptor were discharged to the Roxbury Canal.
- b. All flows from the Dorchester Brook Sewer were discharged to the South Bay.
- c. All flows from the Stony Brook Interceptor were discharged to the tidal estuary of the Charles River via the Old Stony Brook Conduit and the Boston Marginal Conduit. However, this diversion was already in effect when the collapse occurred, since it was necessary to allow for the construction of the Boston Main Drainage Relief Sewer.

2. A 6 month period or more was required to accomplish repair.

3. The loss of Massachusetts Avenue as a major traffic artery during the period required for repair.

4. Repair costs of approximately \$250,000.

According to Sewer Division personnel, operational problems with the sewers, consist almost entirely of blockage of pipes and catch basins due to improper use, refuse, sticks, rags, grease, etc., and sediments or other foreign matter. These operational problems occur, for the most part, in the smaller size pipes and conduits. The larger size conduits in the system are relatively free from the above-mentioned problems.



Maintenance personnel of the Sewer Division indicate that the West Side Interceptor in Dalton Street, adjacent to the Prudential Center site, is in bad condition. At present, the City of Boston plans to abandon this section of the Interceptor and relocate it.

Tidewater infiltration into the Boston Main Drainage System adjacent to the waterfront, mostly through faulty tide gates, has long been recognized as a problem. The major source is presumed to be leakage through faulty gates. However, the tide gates along the West Side Interceptor have been replaced within the last 7 or 8 years which has considerably reduced the problem in this Area. Only two of all the regulators originally in the sewer system are now functioning, and most of the remaining regulators have been removed from the chambers. As a result of these conditions the Public Works Department through the Sewer Division has contemplated a study and report upon the condition of the tide gates and regulator structures. In addition, it is understood that the City contemplates undertaking an extensive study of the entire system.

Many of the sewers, particularly those of brick construction, due to age and relatively shallow cover, are subject to the possibility of structural failure due to modern heavy loads and vibrations. For this reason, sewers in those streets that will be repaved or reconstructed in the process of urban renewal, should be checked, in addition to capacity requirements, for depth of cover and structural soundness, before a final decision is made regarding need for reconstruction. This type of investigation has been



undertaken by the Sewer Division in conjunction with the Department of Public Works street improvement program. A preliminary phase of this program is an inspection and/or evaluation, by the Sewer Division, of the sewer and storm drain system in each street where repavement or major street improvements are planned. The sewers have been evaluated with regard to physical condition, expected useful life, structural ability to withstand modern highway loadings, proper operation regarding present flows and the advisability of construction of a separate storm drain in the localized area of the proposed street improvement.

The available data from this program, as it relates to sewer and storm drains in the Back Bay GMRP Area, is tabulated by streets on the following page.

#### Overflows and Pollution

The main combined sewers in the Back Bay GMRP Area discharge low flows to the West Side Interceptor. Overflows from these sewers, numbered 4 through 7 on Exhibit 47-6 and tabulated hereafter, discharge to the Boston Marginal Conduit through overflow conduits in Berkeley, Dartmouth, Fairfield and Hereford Streets. The present surcharged condition of the Boston Main Drainage System limits the available capacity of the West Side Interceptor. This results in a high frequency of overflow from the local systems.

The Boston Marginal Conduit was constructed level with an invert elevation of -1.5 feet, approximately 2' below mean low tide, and a crown elevation of 6.19 feet, approximately 4' below mean high water. Therefore, the



SEWER DIVISION (CITY OF BOSTON)  
TABULATION OF SEWER EVALUATIONS  
CONDUCTED FOR THE  
STREET IMPROVEMENT PROGRAM

Street	From Street	To Street	Size	Material	Date	Function	Adequate for Loads	Operate Properly	Remarks
Beacon	@P.A.#415 @P.A.#428 @P.A.#431 Arlington	Mass.	4'9"x5'6" 10"	Brick	1876 1876 1869 1872 1880 1863 1870 1907	C.S. S.D. S.D. S.D. S.D. S.D. No No No	No No No No No No No No	Yes Yes Yes Yes Yes Yes Yes Yes	West Side Interceptor
Beacon			12"x16" 15" 12" 5'x6' 10"x12" 10"x12"	Brick C.C. C.C. Brick					
Boylston	Berkeley	Dartmouth							No further sewerage works necessary.
Fairfield Gloucester	Beacon Boylston P.A.#443 P.A.#428 Marlborough P.A.#415 Arlington @Berkeley @Clarendon @Dartmouth @Duxeter @Fairfield @Gloucester	Boylston Back Newbury Commonwealth Beacon Mass	6'0"x6'6" 12" 12" 12" 12" 12"	Brick	1872-1881 1880	S.D. S.D. S.D. S.D. S.D. S.D.	No No No No No No	Yes Yes Yes Yes Yes Yes	Rebuild due to age Rebuild due to age Rebuild due to age Rebuild due to age Rebuild Rebuild
Marlborough			6'6"x6'6" 12" 6' 2-12" 6'0"x6'6" 12"	Brick Brick Brick Brick	1866 1870 1867 1870 1872 1870	S.D. S.D. S.D. S.D. S.D. S.D.	No No No No No No	Yes Yes Yes Yes Yes Yes	Rebuild Rebuild Rebuild Rebuild Rebuild Rebuild



SEWER DIVISION (CITY OF BOSTON)  
TABULATION OF SEWER EVALUATIONS  
CONDUCTED FOR THE  
STREET IMPROVEMENT PROGRAM

2.

Street	From Street	To Street	Size	Material	Date	Function	Adequate For Loads	Operate Properly	Remarks
Marlborough Newbury	Gloucester Clarence @ Dartmouth @ Fairfield @ Hereford @ Hereford Dartmouth	Mass. Hereford	12"			S.D.			
			6'0"	Brick	1870	S.D.	No	Yes	Sewerage works completed
			60" x 72"	Brick	1881	S.D.	No	Yes	
			4'9" x 5'6"	Brick	1876	C.S.	No	Yes	
			6'0" x 6'6"	Brick		S.D.	No	Yes	
P.A.#440	Dartmouth	Exeter	18" x 24"	Brick	1870	S.S.	No	Yes	Rebuild-Recommend New Storm Drain
P.A.#441	Exeter	Fairfield	12"		1881-1883	S.S.	No	Yes	Rebuild-Recommend New Storm Drain
P.A.#442	Fairfield	Gloucester	12"		1880	S.S.	No	Yes	Rebuild-Recommend New Storm Drain
P.A.#443	Gloucester	Hereford	12"		1883-1885	S.S.	No	Yes	Rebuild-Recommend New Storm Drain



conduit is only partially effective during low tides and has no capacity whatsoever during six hours of the tide cycle, or about 50 percent of the time, without surcharge over the crown of the conduit. The Marginal Conduit has three overflows located in the Back Bay Area, numbered 1 through 3 on Exhibit 47-6 and tabulated hereafter, which discharge to the Charles River Basin. These overflows are controlled by weirs set at elevation 8.5, in comparison to the controlled elevation of the level of Basin which is 8.0. Since the capacity of the conduit is limited, overflows to the Basin may be frequent.

Studies made in conjunction with the report on "Boston Marginal Conduit Pumping Station - Project 13" in 1958, indicate that overflows to the Basin occurred one day in every ten days, or approximately one quarter of all days of rain. Investigations conducted as part of that study indicate that overflows from the Marginal Conduit are a definite source of pollution to the Charles River Basin. Recent sanitary investigations made in conjunction with the Charles River Basin Elevation Control Project seem to further confirm this conclusion. Additional data regarding levels of pollution in the Basin and the tidal estuary will be forthcoming from these investigations. The proposed MDC pumping station at the downstream terminus of the Marginal Conduit to pump the flow against the tide will reduce pollution by reducing the frequency of overflow to the Basin. The operation of the MDC Sewerage System, by lowering the surcharged condition of the Boston Main Drainage System, will significantly reduce the frequency of overflow to the Marginal Conduit, thereby reducing pollution in both the Basin and the tidal estuary. Provision of separate sanitary sewerage systems in the Back Bay will further reduce pollution in these waters, and increase the effective capacity of the West Side Interceptor.



# OVERFLOWS

Exhibit

47-6

Key No.

Location

Overflow Size  
Sewer Size  
Point of Normal Discharge

Remarks

## Overflows to Charles River Basin

1. Boston Marginal Conduit @ Berkeley St. 10'x7' 8'0" Charles River below Dam Overflows activated at Elev. 8.5
2. Boston Marginal Conduit, W. of Exeter St. 6'6"x6'6" 6'0"x7'8" Charles River below Dam
3. Boston Marginal Conduit, E. of Hereford St. 6'6"x6'6" 6'4"x7'8" Charles River below Dam

## Overflows to Boston Marginal Conduit

4. Beacon St. @ Hereford St. 4'3"x4'3" 8'0"x8'6" West Side Interceptor
5. Beacon St. @ Fairfield St. 3'0"x4'0" 6'0"x6'6" West Side Interceptor
6. Beacon St. @ Dartmouth St. 3'x4' 6'0" West Side Interceptor
7. Beacon St. @ Berkeley St. 4'x5' 6'0"x6'6" West Side Interceptor

## Internal Overflow

8. Boylston St. @ Fairfield St. 4'0"x8'4" 4'6"x8'4" Hereford St. Combined Sewer

Overflows over a pipe to Fairfield St. Sewer.



### Separation of Systems

Separation in this Area will require the construction of main sanitary sewers parallel to the main combined sewers in Berkeley, Dartmouth, Fairfield, and Hereford Streets, and the construction of a system of lateral sewers connecting to these main conduits. The existing combined sewers can be converted to storm drains. To effectively provide completely separate systems, the plumbing of many buildings will have to be revised to separate yard and roof drainage from sanitary flows. This may be accomplished, at least in part, by the rehabilitation program. The first step, however, must be to provide separate systems in the streets.

The total cost of providing separate sanitary sewers throughout the Back Bay Area will range from \$2,500,000 to \$3,000,000, and will involve approximately 18 miles of sewer construction. In addition, the existing combined sewers will require some reconstruction, repair, and modification to utilize them effectively as storm drains. The extent of these revisions can only be determined after the condition and flow in the conduits is known.



CONCLUSIONS

In summary it appears that several conclusions may be drawn on the basis of the information available.

It is concluded that:

- a. Approximately 30 to 40 percent of the Back Bay GMRP Area is served by a separate sanitary sewerage system discharging to the West Side Interceptor.
- b. The remainder of the Area is served by combined sewers discharging low flows to the West Side Interceptor and overflows to the Boston Marginal Conduit.
- c. Recent surcharging in the West Side Interceptor is attributed to infiltration through the conduit, entrance of tidewater through faulty tide gates in other parts of the system, and the inability of the Calf Pasture pumping facilities to handle the discharge due to their frequent need of repair. Completion of the Metropolitan District Commission Plan will eliminate the need for the Calf Pasture Pumping Facilities.
- d. The Metropolitan District Commission Sewerage Plan, when complete and in operation, will provide significant relief of the West Side Interceptor by diversion of flow to the Boston Main Drainage Relief Sewer. This diversion will probably result in a substantial reduction in the existing surcharged condition.
- e. The main combined sewers are generally adequate for storm frequencies of from 10 to 25 years.
- f. Flow measurements at selected points throughout the systems are necessary to serve as a sound basis for hydraulic analysis of flows to evaluate the adequacy of individual conduits.



g. Details of overflow structures and sewer conduits are not available in several locations where this data is necessary for analysis of the systems. This data will be necessary for further analysis of the system.

h. Occurrence of overflows from the local combined system to the Boston Marginal Conduit may be frequent as a result of the surcharged condition of the West Side Interceptor.

i. Previous studies indicate that the Boston Marginal Conduit overflows to the Charles River Basin approximately one day in every ten days, or approximately one quarter of all days of rain.

j. The overflows from the Boston Marginal Conduit are definite sources of pollution to the Charles River Basin.

k. The operation of the MDC Sewerage System will significantly reduce the frequency of overflow to the Marginal Conduit, thereby reducing pollution in both the Charles River Basin and the tidal estuary.

l. Construction of the Proposed Boston Marginal Conduit Pumping Station by the MDC will significantly reduce the frequency of overflows and resultant pollution to the Charles River Basin, as well as surcharging in the local combined systems.

m. The Charles River Basin Elevation Control Project will prevent the re-occurrence of flooding of low areas in the Back Bay as resulted from hurricane storms in 1954 and 1955.

n. None of the regulator chambers in the Back Bay GWRP Area contain regulators.



o. The physical condition of the conduits, most of which are 50 to 90 years old, is essentially unknown. Sufficient data is not available to effectively analyze the physical condition of these systems.

p. Provision of separate systems throughout the Back Bay Area would result in the near elimination of overflows of sewage to receiving waters, and increase the effective capacity of the West Side Interceptor. The cost of providing this separation exclusive of costs of reconstruction or repair of existing conduits, due to poor condition or inadequacy, will range from 2.5 to 3 million dollars.

#### RECOMMENDATIONS

In summary, on the basis of available information, it appears that the best interests of the Development Program will be served by the following recommendations.

It is recommended that:

a. A program of gaugings and field observations be undertaken at selected points in the systems to provide a determination of typical dry weather flows and storm flow conditions for present land use.

b. A field inspection survey of the physical condition of the conduits be undertaken. Emphasis in this survey should be placed on major conduits, particularly the West Side Interceptor, and the systems in those areas planned for redevelopment, extensive rehabilitation, or where either will cause an extensive change in land use patterns. Prior to undertaking this program, an evaluation should be made of the condition data previously obtained in other Renewal Areas, and other data that may become available from investigations by the Sewer Division.



c. Provision be made in future studies for a field determination of details of selected overflow structures and sewer conduits where the data is not known and is necessary for analysis of the systems.

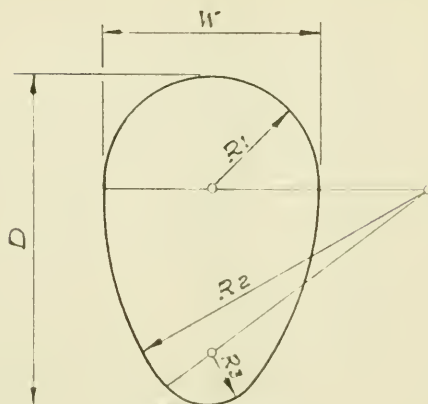
d. Regulator chambers in the Back Bay Area be inspected and the regulators replaced and the chamber be repaired or reconstructed as required, consonant with the final plan for modification of the systems.

e. Separate systems for sanitary sewage and storm flow be provided to the maximum extent practicable, depending upon: future land use planning, the extent of reconstruction of streets, condition of existing sewers, the extent of other utility work required in the area, and the extent to which separation of existing building drainage is effected under the rehabilitation program.

f. An overall study be initiated to determine the combined effect that the operation of the MDC system, and the Urban Renewal Program will have upon flows in the Boston Main Drainage System.



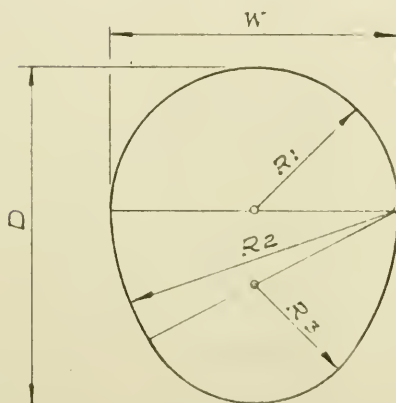
TYPICAL SECTIONS  
EXISTING SEWERS  
—BACK BAY—



EGG

$W \times D$	$R_1$	$R_2$	$R_3$
24" x 36"	12"	36"	6"
* 36" x 48"	18"	42"	12"

\* Modified

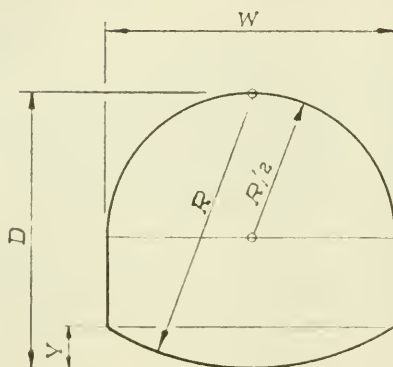


OVOID

$W \times D$	$R_1$	$R_2$	$R_3$
24" x 31"	12"	24"	7 1/8"
30" x 36"	15"	30"	13"

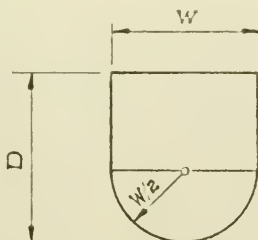


TYPICAL SECTIONS  
EXISTING SEWERS  
 — BACK BAY —



HORSESHOE

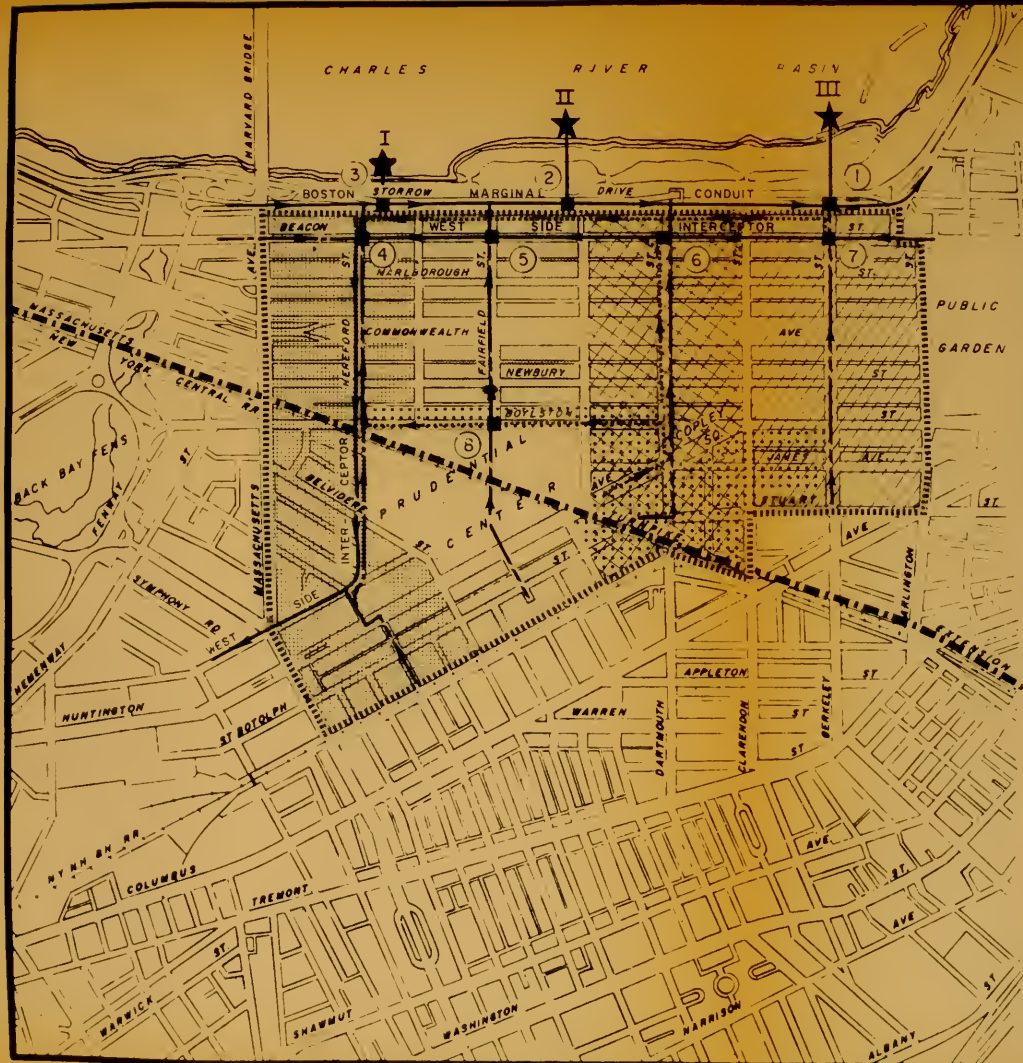
$W \times D$	$R$	$Y$	$W \times D$	$R$	$Y$
27" x 27"	27"	3 <sup>5</sup> / <sub>8</sub> "	42" x 42"	42"	5 <sup>5</sup> / <sub>8</sub> "
36" x 36"	36"	4 <sup>3</sup> / <sub>8</sub> "	51" x 51"	51"	6 <sup>7</sup> / <sub>8</sub> "



U SHAPE

$W \times D$	$W \times D$
18" x 18"	18" x 66"
18" x 33"	36" x 64"
18" x 36"	





REPORT ON UTILITY SYSTEMS  
 BACK BAY GNRP AREA  
 PROJECT NO. MASS. R-47  
 MAIN INTERCEPTORS  
 POINTS OF POLLUTION AND  
 TRIBUTARY AREAS

EXHIBIT 47-6

BOSTON REDEVELOPMENT AUTHORITY

SCALE 1"=800' DATE JULY 19, 1963

CHARLES A MAGUIRE & ASSOCIATES  
 ENGINEERS



## WATER SYSTEMS

### GENERAL

The City of Boston, in 1848, obtained its municipal water supply from Lake Cochituate through the Cochituate Aqueduct and the Brookline Reservoir. In order to maintain satisfactory service, the City found it necessary, in 1866, to construct the Chestnut Hill distributing reservoir and, subsequently, additional reservoirs on the Sudbury River with the Sudbury Aqueduct feeding the Chestnut Hill Reservoir.

The Metropolitan Water District was formed in 1895, and by 1908 the Wachusett Dam, Reservoir and Aqueduct had been completed. The Metropolitan District Water Supply Commission was formed in 1926, and since then has built many of the present day facilities, such as the Swift and Quabbin Reservoirs, the Wachusett-Coldbrook Tunnel and the City Tunnel. These facilities are presently under the control of the Metropolitan District Commission (MDC).

### METROPOLITAN DISTRICT COMMISSION SYSTEM

The Water Division of the Metropolitan District Commission is responsible for collecting, storing, conveying, and distributing water to the City of Boston and other metropolitan cities and towns.

The entire water supply is obtained from four watersheds; namely, the Swift, Ware, Nashua, and Sudbury Rivers, in the western part of the State. The reservoirs of these watersheds have a combined storage of 496 billion gallons of water and a safe yield of 340 million gallons per day. The total consumption of the Metropolitan District is approximately 223 million gallons per day, while the total consumption by the City of Boston is in the range of 120 million gallons per day, or about 170 gallons per capita.



Water is supplied to the Metropolitan Area from Quabbin Reservoir on the Swift River, through the Quabbin Aqueduct to the Wachusett Reservoir on the Nashua River at Clinton. From the Wachusett Reservoir it continues through the Wachusett Aqueduct into the Weston and Hultman Aqueducts. The Hultman Aqueduct, referred to as the "Pressure Aqueduct," continues eastward to the Norumbega Reservoir, and then through the City Tunnel to Chestnut Hill. The Weston Aqueduct terminates at the Weston Reservoir, from which water flows directly into the MDC distribution mains.

The MDC supplies six separate services to the Metropolitan Area; two are supplied by gravity and the other four are pumped from the two gravity services. The two gravity services are the Low Service and the Southern High Service. The Low Service is further geographically subdivided into the Southern and Northern Low Services. Of the six services, the Low Service, Southern High Service, Northern High Service, and the Southern Extra High Service supply the City of Boston. Only the Southern Low Service and the Southern High Service serve the Back Bay GNRP Area.

The Southern Low Service supplies City Proper, Roxbury, South Boston, Brighton, West Roxbury, and Dorchester by gravity from the Weston Aqueduct by means of 60 inch and 48 inch lines. Connections at the shafts on the City Tunnel at Chestnut Hill are used to supplement the supply to the low service through the use of regulators. In addition, the service can be supplied from the Chestnut Hill Low Service Pumping Station; however, this source of supply is usually held in reserve.



The Southern High Service, in addition to fringe areas, supplies a large section of Boston, including Brighton, Roxbury, West Roxbury, Dorchester, and Hyde Park by gravity from the Norumbega Reservoir, through the City Tunnel, to Chestnut Hill. In periods of peak demand, usually during the summer months, the High Service Pumping Station at Chestnut Hill, supplied by the Chestnut Hill Reservoir, supplements this service.

#### CITY OF BOSTON SYSTEM

The water system in the City of Boston is owned and operated by the City of Boston. The system is administered by Mr. James W. Haley, Commissioner of Public Works. The Water Division of the Public Works Department is under the direction of Mr. Edward Pinkul, Water Division Engineer, and consists of the Engineering Branch, the Distribution Branch, and the Income Branch. The Distribution Branch is subdivided into three maintenance areas; each responsible for the distribution system in a specific section of the City, including Boston Redevelopment Authority designated areas, as follows:

AREA I - includes the Downtown, East Boston, Roxbury-North Dorchester, Back Bay, and Parker Hill-Fenway GNRP Areas, a small northern section of the Jamaica Plain GNRP Area, and the South End Project Area. The maintenance yard for Area I is located at 710 Albany Street, with Mr. Albert McCann, Area Supervisor, in charge.

AREA II - includes the remaining portion of the Jamaica Plain GNRP Area not included in Area I. The maintenance yard is located at Forest Hills. Mr. Phillip Reddy is the Area Supervisor.



AREA III - includes all of the South Boston and the eastern part of the Roxbury-North Dorchester GNRP Areas. The maintenance yard for this area is located on Hancock Street in Dorchester, and is under the direction of Mr. Edward Beckworth, Area Supervisor.

#### BACK BAY GNRP AREA

The Southern Low Service and the Southern High Service supply the Back Bay GNRP Area and are described hereafter.

#### Southern Low Service

This service, consisting of mains ranging in size from 6 inch to 48 inch in diameter, extends throughout the majority of the GNRP Area, and delivers approximately 90 percent of the total water consumed in the Back Bay. A total of 2.72 miles of low service water main, 16 inch and greater in diameter, exists in the Area in the following distribution: 0.87 miles of 16 inch, 0.92 miles of 40 inch, and 0.93 miles of 48 inch. Most of these low service mains were laid from 1920 to 1940 with a considerable length of the 40 inch main dating back as far as 1859.

A limited number of pressures measured and recorded in 1950 by the National Board of Fire Underwriters (NBFU), varied from 25 to 65 psi throughout the entire service and from 50 to 60 psi in the GNRP Area. The present range of pressures in the Area may differ somewhat due to the limited number of tests conducted by the NBFU, and adjustments made at MDC reservoirs, pumping stations, and flow regulators.



The majority of the low service mains, 16 inches and larger, are unlined cast iron; however, a small percentage is cement lined. These mains provide most of the domestic, commercial, manufacturing supply, and fire protection to the GNRP Area.

Three low service trunk mains listed hereafter, and shown in Exhibit 47-7, extend into and through the Back Bay GNRP Area. These trunk mains, by divergency and interconnection, having partially supplied the Parker Hill-Fenway Area, provide the low service supply to Back Bay and, in addition, supply the South End, the downtown areas, and South Boston.

1. A 48 inch main extends along Commonwealth Avenue throughout the Back Bay GNRP Area. This main provides a substantial supply to Back Bay and the downtown areas.
2. A 24 inch main begins at the 48 inch main in Commonwealth Avenue at Massachusetts Avenue, follows Massachusetts Avenue, reduces to a 20 inch main on the New York Central Railroad bridge, increases to 24 inches, then follows Massachusetts Avenue to a point where it connects to the 48 inch main in Tremont Street. This main serves primarily as a cross connection between the 48 inch main in Tremont Street, and the 48 inch main in Commonwealth Avenue.
3. A 40 inch main extends along Beacon Street throughout the Back Bay GNRP Area. This main, in conjunction with the 48 inch main in Commonwealth Avenue, provides a principal supply to Back Bay and the downtown areas.



### Southern High Service

This service, consisting of mains ranging in size from 6 inches to 42 inches in diameter, supplies localized portions of the GNRP Area and delivers approximately 10 percent of the total water consumed in the Back Bay. A total of 2.25 miles of high service mains, 16 inches and greater in diameter, exists in the Area in the following distribution: 1.15 miles of 16-20 inch, 0.04 miles of 24 inch, and 1.06 miles of 42 inch. Most of these high service mains were laid from 1889 to 1920. However, a considerable length of the 42 inch main was laid in 1939.

A limited number of pressures, measured and recorded in 1950 by the NBFU, varied from 18 to 95 psi throughout the entire service and from 60 to 75 psi in the GNRP Area. The present range of pressures may differ somewhat due to the limited number of tests, conducted by the NBFU, and adjustments made at MDC reservoirs, pumping stations, and flow regulators.

The majority of the high service mains, 16 inches and larger, are unlined cast iron; however, a small percentage is steel. These mains supplement the low service for domestic and commercial supply and fire protection, in limited portions of the Area.

Two high service trunk mains listed hereafter and shown in Exhibit 47-7, extend into and through the Back Bay GNRP Area. These trunk mains, by divergency and interconnection, having supplied the Parker Hill-Fenway Area, and to a minor extent South End, provide the high service supply to Back Bay and the downtown areas.



1. A 42 inch main enters the Area in St. Botolph Street at Massachusetts Avenue and follows St. Botolph Street, Irvington Street, Huntington Avenue, reduces to a 36 inch main across Boylston Street, then increases to 42 inches along Clarendon and Newbury Streets, through the Back Bay GNRP Area. This main is the principal high service supply to Back Bay and the downtown areas.
2. A 20 inch main enters the area in Huntington Avenue at Massachusetts Avenue and follows Huntington Avenue and Boylston Street through the Back Bay GNRP Area. This main serves primarily as the local distributor of high service, from the 42 inch main.
3. A 20 inch main is connected to the aforementioned 20 inch main in Huntington Avenue at Massachusetts Avenue, increases to a 24 inch main, then follows Massachusetts Avenue to the south and connects to the 30 inch main in Columbus Avenue. This main serves primarily as a cross connection between the 20 inch main in Huntington Avenue and the 30 inch main in Columbus Avenue.



### Interconnection of Services

The low service and the high service are interconnected through division gates, normally closed to maintain the pressure differential, at several points in the system, insuring supplementary fire protection and domestic supply in the event of failure of either service. There is one division gate in the GNRP Area located at Clarendon Street and St. James Avenue, connecting a 12 inch high service main to a 12 inch low service main.

### ANALYSIS OF EXISTING SYSTEMS

The existing data regarding the water system has been compiled from a variety of sources which are categorized as follows: records of main failures, water waste survey reports, fire flow tests, pressure records, personal interviews with City Water Division personnel, records of water main cleaning, the 1951 National Board of Fire Underwriters (NBFU) "Report to the City of Boston," the Capital Improvements Program of the City Water Division, and the Analysis of Metropolitan District Commission Water. Records specifically concerned with condition of mains or detailed water main condition data do not exist. A discussion of each category of available data follows:

#### Main Failures

This information is available in memo form and lists the time, date, size, location, and type of break. The breaks and leaks are listed as three types: (1) Joint leak, a withdrawal of caulking material from the bell and spigot; (2) Circumferential or circular break; (3) Longitudinal or lengthwise break. The locations of the various type failures are shown in Exhibit 47-7.



Although the type of break is readily apparent, the cause is influenced by many variables inherent in the manufacture, laying, and environment of the main.

The following lists some of the causes of the various types of failures:

Joint Leak: Improper caulking or bedding during construction, interference by other underground construction, periods of high water temperature, caulking compound failures, corrosion, pipe settlement and traffic induced vibrations.

Circumferential Break: Faulty bedding during construction, interference by other underground construction, periods of cold weather and low water temperature, ground movement, corrosion and pipe material failure.

Longitudinal Break: Interference by other underground construction, excessive pressure, corrosion and pipe material failure.

Data on main failures are being collected, analyzed, and evaluated for all the GNRP Areas. The final report will include these data and their evaluation since data for an Area individually is not extensive enough to be conclusive. Preliminary investigations do, however, give an indication of the results and conclusions that may be drawn. The following tabulations indicate pertinent data relative to the Back Bay GNRP Area.

MAIN FAILURES 1954-1962

(16 inches and larger)

	<u>Total Miles</u>	<u>Total Failures</u>	<u>Av. Pressure</u>	<u>Failures/Mile</u>
HS.	2.25	3	70 psi	1.33
LS.	2.72	0	55 psi	0.00



JOINT LEAKS BY AGE

(16 inch and larger)

1954 - 1962

<u>Age</u>	<u>High Service</u>			<u>Low Service</u>		
	<u>Miles Main</u>	<u>Leaks</u>	<u>Leaks/ Mile</u>	<u>Miles Main</u>	<u>Leaks</u>	<u>Leaks/ Mile</u>
101-110	0.00	0	0.00	0.92	0	0.00
91-100	0.00	0	0.00	0.00	0	0.00
81-90	0.00	0	0.00	0.21	0	0.00
71-80	0.74	0	0.00	0.18	0	0.00
61-70	0.62	2	3.21	0.00	0	0.00
51-60	0.03	0	0.00	0.03	0	0.00
41-50	0.15	0	0.00	0.00	0	0.00
31-40	0.00	0	0.00	0.78	0	0.00
21-30	0.50	0	0.00	0.59	0	0.00
11-20	0.21	0	0.00	0.01	0	0.00

Circumferential and longitudinal failures are not of significant numbers to be presented here, but will be considered in the overall analysis of the system.

The following conclusions are indicated from a review of the preceding tables and Exhibit 47-7. Although the data presented is limited, the conclusions do follow general trends established in previous reports.

1. The failure per mile ratio is greater in the high pressure service than in the low pressure service.
2. The high incidence of main failures, reported along Boylston Street and Huntington Avenue, as shown in Exhibit 47-7, may



be the result of concentrated MTA facilities and recent construction activity in those areas.

3. Joint leaks occurred mostly in mains 12" and larger.
4. Structural (longitudinal and circumferential breaks) failures occurred mostly in mains 12" and smaller.
5. Mains 16 inches in diameter and greater in the low service did not require major maintenance.
6. Possibly more definite trends and some empirical relationships can be developed with the analysis of data from all the GNRP Areas to aid in establishing a useful life for water mains in the Boston System.

#### Water Waste Surveys

The first water waste survey in Boston was conducted in 1920 by Pitometer Associates of New York. Since that time similar surveys were conducted in 1940 and 1960.

The primary purpose of the water waste survey is to locate undetected leaks in the various districts throughout the system. Leaks in mains, under-registration of meters, illegal water connections, closed valves and faulty valves have been reported as a result of these surveys. The investigation usually is limited to the smaller mains, up to 12 inches in diameter.

In the surveys of 1920 and 1940, it was the practice to make 24 hour measurements of flow; however, this practice has been discontinued and only short duration measurements are now made since excessive sedimentation and incrustation in the smaller mains causes plugging of the pitometer during extended test periods.



As part of the water waste survey, pitometers are introduced into the mains at gauging points to measure velocities of flow in increments across the diameter of the pipe. These velocities are then used to determine the velocity factor (a ratio of the present average velocity to the theoretical average velocity of new pipe). In recent surveys, prior to velocity measurements, physical measurements were made of incrustation and inside diameter of pipe from solid metal to solid metal.

These data, the velocity factor and measurement of incrustation may be used in evaluating the effect of age on pipe capacity; however, sufficient data has not been assembled at this time to permit conclusions to be drawn.

Data regarding leakage discovered, miles of main investigated, and total daily consumption for each survey district, were assembled from the water waste survey reports of 1920, 1940, and 1960, and analyzed for the Back Bay GNRP Area. Although the data presented is such, that each category of data cannot be directly compared and evaluated for a 40 year period, a number of general trends and conclusions are indicated.

The reports indicate that:

1. Leakage was discovered only in the 1940 survey and was limited entirely to the low service.
2. No major leaks were discovered as a result of the 1960 survey.
3. Water demands in this GNRP Area have been steadily increasing by a rate of 40 percent per 20 year period.



From the data presented here, together with other related data, it appears that the major components of the distribution system are structurally sound. However, present known data is not sufficient to permit an evaluation of physical condition, to the degree of accuracy necessary to make a determination of useful life.

#### Fire Flow Tests

One of the most direct methods of determining the hydraulic performance of existing distribution systems is to conduct fire flow tests. The ability of the mains to deliver the required flows can be readily assessed by a limited number of these tests.

The Back Bay GNRP Area contains a large number of four and five story masonry residential structures, commercial and minor industrial districts along principal thoroughfares, and an extensive institutional district located in the southern section of the Area. Requirements of the NBFU indicate a flow of 5000 gpm at 20 psi, from a group of hydrants that might be utilized in fighting a serious fire, to be adequate for this type area.

In Report Number 158, May 1951, the National Board of Fire Underwriters presented the results of group hydrant flow tests conducted throughout the City of Boston. Two of the group test locations conducted by the NBFU, and one single hydrant flow test conducted by the City of Boston Water Division since that time, are within the limits of the Back Bay GNRP Area. The locations and results of these tests are shown in Exhibit 47-7, together with other pertinent data observed at the time of the test.



The test by the City of Boston was conducted at Commonwealth Avenue and Exeter Street, with a single hydrant flowing, in order to yield specific information needed by the Water Division in operating the distribution system, and as an indication of fire protection available. It resulted in a flow of 2300 gpm at 20 psi, which satisfies the requirement of 1000 gpm needed to support four separate fire streams or a modern fire pumper apparatus. The results of the single hydrant test further indicates that if a group of hydrants were flowing at that location, as required by NBFU criteria for determination of adequacy of fire protection, they would undoubtedly satisfy the 5000 gpm NBFU group test requirement for Back Bay.

The results of the two group hydrant flow tests conducted by the NBFU, on the low service, indicate considerable strength in the system at these locations. The test at St. Botolph and Garrison Streets produced a flow of 7700 gpm at 20 psi and the test at Beacon and Gloucester Streets produced a flow of 9600 gpm at 20 psi.

Flow tests in the low service system and other related data indicates that strength in the larger arteries and in the gridiron of smaller mains, in the vicinity of these tests, is sufficient to produce adequate flows. However, due to the limited number of flow tests available, it cannot be determined at this time whether deficiencies in fire protection exist in the system of high service mains or the gridiron of smaller mains in the remainder of the low service area.



### Pressure Records

Pressure records of both the low service and high service are maintained at several locations in the City. A review of the records extending back 30 years indicated no trend of pressure variation. This is due to adjustments made at MDC reservoirs, pumping stations, and flow regulators.

Several pressure recording gauges are maintained by the Water Division throughout the City of Boston, none of which are within the limits of the Back Bay GNRP Area. However, static pressures have been measured and are recorded on plans maintained by the Water Division in order to indicate weak points in the distribution system. There are none apparent in the Back Bay GNRP Area.

Pressures in both services recorded in this Area appear to be adequate for domestic services and fire protection. Current pressure records and past records available would be valuable in any further hydraulic investigation or analysis of the system.

### Personal Interviews

Personnel of the Water Division were interviewed to determine their points of view regarding adequacy of capacity, condition, operating problems and special problems of the system in the Back Bay GNRP Area. The opinions expressed were not the result of hydraulic tests or a thorough analysis of records, but were the result of experience in working closely with the system for many years. Their comments and opinions are summarized as follows:



1. All mains 16 inches in diameter and greater, many 60 to 100 years old, are considered hydraulically and structurally to be in good condition; however, considerable tuberculation exists in the older and smaller mains. To remedy this, a program of cleaning and cement lining is under consideration as outlined in the Capital Improvement Program of the Water Division.
2. The Metropolitan District Commission mains to the city are considered to be adequate at the present time.
3. The City of Boston transmission mains are considered to be capable of delivering an adequate volume of water to the Back Bay GNRP Area and other areas of the City.
4. The construction of the Prudential Center has provided part of the Area with a gridiron of new water mains, particularly in the smaller sizes. None of the mains 16 inches or larger is affected by this project.
5. There has been limited cleaning and cement lining of the existing system accomplished in recent years in certain areas of the City; however, none of the mains in the Back Bay GNRP Area have been cleaned and cement lined.
6. The existing system for the most part has a minimum cover of five feet. No freezing of mains has occurred in the past 45 years, except in minor cases such as dead ends or small sizes.



Data on specific deficiencies in the Back Bay GNRP Area, other than those mentioned are not available because an engineering study of the system has not been made since installation. Most problems are confined to day-to-day operation. Maintenance is carried on as the need becomes readily apparent.

#### Cleaning of Water Mains

A program of cleaning approximately 100 miles of 6 inch to 16 inch water main throughout the Boston system was accomplished between 1913 and 1927. However, none of the mains in the Back Bay distribution system are indicated as having been cleaned.

#### National Board of Fire Underwriters Report of May 1951

The City of Boston facilities for fire protection were the subject of a comprehensive report published in 1951 by The National Board of Fire Underwriters. The report was based upon field tests and a compilation of recorded data regarding the pertinent facilities.

The water supply and distribution system was a prime consideration in the report. Those pertinent comments and conclusions included in the report have been summarized herein. It must be understood that these comments and conclusions were not drawn with respect to any specific section of the city, such as the GNRP Area covered by this Interim Report. The NBFU comments and conclusions are summarized as follows:

Pertinent Comments: The gridiron of distributors in the Southern High Service is generally strong. The interior of most pipes is considerably tuberculated thereby seriously reducing their carrying capacity. Considerable pipe was cleaned in 1920 to 1927, principally in East Boston, but judging



from experience in other cities, any gain in carrying capacity has been lost. Discharge from hydrants contained considerable sediment.

Breaks in mains are infrequent and are generally attributed to other underground construction. No recent trouble from electrolysis is reported. The main arteries are well gated and, on the distribution mains, valves are generally located so that not more than 2 or 3 hydrants would be affected by a broken main. The average length of main which would be shut off in consequence of a single break, in representative residential districts, outside the congested value district, would be 590 feet.

The number of fire flow tests conducted was limited by the Water Division in order to minimize the disturbance of sediment in the distribution system.

Conclusions: An ample and reliable supply is provided to the City by the Metropolitan District Commission. Pressures are usually adequate except for a few high locations. The extension of the Southern High Service into areas served by the Low Service provides good primary supplies for automatic sprinklers, and has been utilized so extensively that the maintenance of normal pressure in this service is of prime importance from a fire protection viewpoint.

Within the City, arteries to the congested value district are generally sufficient in number and capacity. In other areas, particularly in the outer parts of the service limits, additional strength is warranted.

Fire flow tests indicate that in most areas quantities are generally satisfactory except near the outer service limits. A comparison of flow



tests made at this time with those made during previous surveys indicates that the carrying capacity of the pipe is considerably reduced by tuberculation. To make a more satisfactory study of the distribution system, many more tests would have been desirable.

The gridiron of minor distributors is good and generally complete. The gridiron is strengthened by the commendable practice of using no pipe smaller than 8 inch and installing mainly 12 inch in new installations and by replacing smaller pipe with these sizes.

#### Capital Improvement Programs

A review of the water works phase of the City of Boston Capital Improvement Program as prepared by the Water Division Engineer, indicates that recommended improvements are based on increased population and fire demands and are intended as an aid to proposed building activities.

Those improvements and comments from the program that are pertinent to the Back Bay GNRP Area have been excerpted and are summarized hereafter.

Some of this program has been effected to date, but only to a limited degree.

#### Proposed Improvements & Comments (1954-1961) as Submitted to the City Planning Board

1. Re-lay all 6 inch mains laid before 1890 and parts of the eleven miles of 4 inch to 30 inch mains laid over 100 years ago.
2. Six inch diameter mains in the older sections of the City were considered inadequate due to increased domestic consumption and fire protection.



3. The older sections of the City are being changed from single residences to multiple apartments and rest homes requiring increased domestic consumption and greatly increased fire protection. Examples given relative to the Back Bay GNRP Area are in the vicinity of Commonwealth Avenue and Beacon Street.
4. Improvements are proposed to replace old and inadequate water mains in residential and business areas of the City.

Proposed Improvements & Comments (1963-1969) as Submitted to the Boston  
Redevelopment Authority

1. Clean and cement line smaller sized distribution mains on a city-wide basis.
2. Re-lay inadequate mains and extend distribution mains on a city-wide basis.
3. Extension of water mains is necessary to properly supply existing domestic and business requirements. In addition, anticipated demands must be considered to satisfy a more reasonable residual pressure for fire fighting and domestic purposes.
4. If these improvements are not completed within the next five years, an increased fire hazard, and detriment to public health would result. It is estimated that 100 people per acre would be without proper water service.



5. The useful life for each improvement is estimated to be a minimum of 50 years for cement lining and 100 years for newly installed mains. The construction program costs were estimated at \$200,000 per year on a city-wide basis for each category.
6. These improvements have been in demand for the past ten years and are needed to satisfy increased requirements for fire and domestic consumption.

#### Analysis of Metropolitan District Commission Water

Corrosion of water mains has a relationship to some of the characteristics of the water itself. Those characteristics are:

1. Carbon dioxide content.
2. pH (measure of hydrogen-ion concentration).
3. Alkalinity.
4. Dissolved oxygen content.
5. A chemical environment conducive to the growth of iron bacteria.

Although all of the aforementioned characteristics are responsible to some degree for tuberculation and incrustation, the major contributing factor is found in the relationship between alkalinity, carbon dioxide content, pH value and dissolved oxygen content. An analysis of MDC water conducted in February, 1963, by the Massachusetts State Board of Health at the Weston Reservoir terminal chamber indicated:

pH (hydrogen-ion concentration)	6.6
Alkalinity (expressed as calcium carbonate hardness)	7.3 ppm
Free Carbon Dioxide content	4.0 ppm



These values, when plotted on curves developed by the New York State Department of Health (Fig. 1 and Fig. 2), indicate that the water has a relatively high degree of corrosiveness.

Alkalinity, carbon dioxide content, and dissolved oxygen content affect the rate of corrosion and at the same time are reflected in the pH value. Data collected in 1935 from actual field tests on water mains in other cities by the Committee of Pipe Coefficients of the New England Water Works Association (NEWWA) further illustrates this correlation. Water with values of pH similar to those found in MDC samples indicated a 54 percent reduction in capacity for cast iron mains in a 30 year period. Although the correlation of pH to loss in capacity is based on actual field conditions found in other cities, further adjustments are necessary to compensate for local conditions.

The foregoing indicates that unlined cast iron mains in the Boston system may have a shorter useful life than is indicated by the Hazen-Williams predicted average trend.



### Evaluation of Existing Mains

Data from main failures, water waste surveys, fire flow tests, pressure records and personal interviews were analyzed, as an aid in evaluating the capacity and condition of mains presently in use in the Back Bay Area. This data indicates generally that mains 16 inches and larger are structurally sound and are capable of delivering strong flows in most instances.

Nearly half the total miles of main, 16 inches and larger, in the Back Bay GNRP Area, were laid prior to 1900 and are considered to be tuberculated to some extent. However, present known data is not sufficient to permit an evaluation of their physical condition or capacities, to the degree of accuracy necessary to make a determination of adequacy and useful life.

A preliminary hydraulic analysis of the trunk main system was conducted in the Back Bay Area, to determine generally, the adequacy and/or apparent deficiencies of the larger sized mains. The analysis was based on "C" values from the Hazen-Williams predicted average trend, estimated present and future demands, a 100 year economic useful life of water mains, and an allowance for increased domestic commercial and fire demands for the Prudential Center.

The results of this analysis indicated:

1. The 80 year old 16 inch low service main in Exeter Street may be approaching its capacity limits and is in need of cement lining or replacement.



2. The 100 year old 40 inch low service main in Beacon Street, although adequate in capacity may be approaching the end of its useful life and in need of replacement. However, the results of field inspection and field tests may indicate this main to be in good condition.
3. The 80 year old 24 inch low service main in Massachusetts Avenue, which serves primarily as a cross connection between the 48 inch main in Tremont Street and the 48 inch main in Commonwealth Avenue, is considered to be badly tuberculated and is estimated to have lost over 50 percent of its original carrying capacity. Although demands on this main are estimated to be relatively small, cleaning and cement lining of the main would result in a more flexible system of trunk mains.
4. The 70 year old 42 inch high service main in Huntington Avenue and Newbury Street, although estimated to be adequate in capacity and condition, is considered to be of vital importance in maintaining high service pressure and supply to City Proper. It is, therefore, recommended that this main be further evaluated by field inspection, where possible, and by hydraulic tests.
5. The 75 year old 20 inch high service main in Huntington Avenue and Boylston Street, appears to be inadequate in capacity to meet present demands, and is in need of either cement lining or replacement



It is recommended that those portions of the aforementioned mains to be exposed during the construction of the Massachusetts Turnpike Extension, see Exhibit 47-7, be inspected for physical condition. The results of this inspection could serve as an indicator of other mains of similar age and material.

The final decision for replacement or cement lining the aforementioned mains should be based on a field inspection of a portion of the main as previously recommended for those mains crossing the turnpike, coupled with hydraulic tests to determine their physical condition and hydraulic capacities. It is strongly recommended that the final decision should also be based on a complete study of the arterial system, when planning for all GNRP Areas is available.

Estimated Costs for Replacement and Restoration of Mains: A tabulation of mains, previously selected for replacement or restoration by the preliminary hydraulic analysis in the section entitled "Evaluation of Existing Mains," is presented hereafter, together with estimated costs. These costs consider entirely new appurtenances on mains to be replaced, partial replacement of appurtenances on mains to be cleaned and cement lined, and a factor of 21 percent for engineering, contingencies, and construction cost increases. These costs are presented to serve as a guide in preliminary planning and as an aid in establishing costs for the development program.



SELECTED MAINS

ESTIMATED COSTS OF REPLACEMENT AND RESTORATION

Size	Service	Year Estab- lished	Length	Location	Cost of Re- placement with New Main	Cost of Cleaning and Cement Lining
16"	L.S.	1872-1887	2000'	Exeter St.	\$ 70,000	\$20,000
40"	L.S.	1859	5000'	Beacon St.	\$430,000	\$60,000
24"	L.S.	1883	2700'	Massachusetts Ave.	\$130,000	\$30,000
20"	H.S.	1889	3300'	Huntington Ave.) Boylston St.	\$120,000	\$40,000
42"	H.S.	1895	3100'	Huntington Ave.) Newbury St.	\$280,000	\$40,000

**CONCLUSIONS**

In summary on the basis of available information, it appears that several conclusions can be drawn.

It is concluded that:

a. The Metropolitan District Commission supply mains are considered to be fully adequate in capacity to satisfy present demands.

b. The City of Boston distribution system in the Back Bay Area appears to be generally sound structurally, and adequate in capacity for present demands, including fire protection and pressure requirements; however, several components of the system have apparent deficiencies that can be remedied by replacement or rehabilitation.

c. The following conclusions were used as the basis, in the preliminary analysis of the distribution system in Back Bay, for considering mains for replacement and rehabilitation:

1. The economic useful life of water mains is estimated to be 100 years.



2. The useful life of the distribution system should be extended at least 20 years to be compatible with construction of new pavements.
3. The Prudential Center Project increases domestic and fire demands in the Area.
4. The "C" values from the Hazen-Williams predicted average trend are the most reliable means presently available for determining coefficients for mains in the Boston distribution system.

d. Final determination of adequacy and condition must be made based upon future land use plans in the Back Bay and other GNRP Areas, hydraulic tests and field inspections to determine the physical condition and hydraulic capacities, and a complete study of the arterial system. However, some of the deficiencies apparent in components of the systems are:

1. Considerable tuberculation exists in the older and smaller distribution mains and to a lesser extent in the larger sized distribution and supply mains.
2. A high incidence of failures, in Boylston Street and Huntington Avenue.
3. The 16 inch low service main in Exeter Street may be in need of rehabilitation to adequately meet present demands.
4. The condition of the 40 inch low service main in Beacon Street is questionable, due to its age.



5. The 24 inch low service main in Massachusetts Avenue may be in need of rehabilitation due to reduced capacity.
6. The 20 inch high service main in Huntington Avenue and Boylston Street may be in need of rehabilitation due to reduced capacity.
7. The 42 inch high service main in Huntington Avenue and Newbury Street requires special evaluation due to its prime importance in maintaining high service pressure and supply to City Proper.

e. Main failure records in this and other previously investigated GNRP Areas indicate that generally mains 16 inches and larger, and all mains laid after 1930, are structurally sound and that the frequency of failure is greater in the high pressure service than in the low pressure service.

f. Analysis of Metropolitan District Commission water indicates that it has a relatively high degree of corrosiveness, and unlined cast iron mains in the Boston System may have a shorter useful life than is indicated by the Hazen-Williams predicted average trend.

g. The results of field tests to be conducted in the South End Project Area, and an inspection of mains exposed during construction of the Massachusetts Turnpike, together with studies of other available data, in all GNRP Areas will provide data for re-evaluation from which additional conclusions may be drawn regarding adequacy and condition of the system.



h. Additional fire flow tests are necessary to accurately determine the fire protection available in areas served by the high service system and portions of the low service system.

#### RECOMMENDATIONS

In summary, on the basis of available information, it appears that the best interests of the Development Program will be served by the following recommendations:

It is recommended that:

a. The National Board of Fire Underwriters be requested to undertake studies, and report on the fire protection facilities of the City as a whole.

b. Consideration be given to the NBFU recommendation as set forth in their Report of May 1951. The major recommendations being, "that a complete study be made of the arterial system and of the deterioration in carrying capacity, including minor distributors." This recommendation was deemed of most importance by the NBFU and urged for early adoption.

c. Consideration be given to a field inspection of portions of those mains to be exposed during the construction of the Massachusetts Turnpike Extension. The results of this program could provide sound data to serve as a basis for determining the physical condition of these and other mains in the Boston System.

d. Consideration be given to replacement or cleaning and lining of every main installed before 1900, especially those located in streets to be reconstructed. The final decision should be based upon a field inspection



of a portion of the main, where possible, coupled with hydraulic tests, to determine its physical condition and hydraulic capacities. Several mains to be included for consideration are listed previously in the conclusions.

e. In conjunction with the above recommendation, it is strongly recommended that city of Boston transmission mains in the Back Bay Area be evaluated for future adequacy by an overall study of the arterial system when more detailed planning for other GMRP Areas is available.

f. Consideration be given to initiation of a comprehensive program involving analysis of the hydraulics of the systems through the use of modern engineering techniques, such as the McIlroy Analysis. This program would provide the Authority with sound engineering data to serve as a basis for optimum, economical modification of the supply and distribution mains as necessitated by the Redevelopment Program. In addition, it could become a continuing program that could ultimately be adopted by the City with highly beneficial short and long range results, including major economies which have been proven in comparable cities in recent years.







## POLICE SIGNAL SYSTEM

### INTRODUCTION

The Boston Police Department, under the supervision of Police Commissioner, Edmund McNamara, in addition to the various subdivisions of its administrative organization, is divided into 15 land areas and one water area called Divisions. Each Division has its own station. These Divisions are under the general supervision of the Superintendent of Police and the direct control of Division Captains. The Department is presently undergoing an extensive reorganization. The reorganized Police Department will consist of fewer Divisions covering larger land areas.

An integral part of the working components of the Police Department is the Police Signal System. It is under the supervision of the Director of Signal Service, Mr. William Malone, who is responsible to the Police Commissioner. That portion of the Signal System with which this report is primarily concerned is the signal box system.

### EXISTING SYSTEM

#### General

The function of the signal box system, first introduced into Boston in the late 1880's is to provide voice communication between the police officer and the police station. The system is essentially subdivided into 15 parts, each of which corresponds with and is a part of its respective Police Division. The police signal system also provides a direct communication system between each Division Station House and between each Station House and Police Headquarters on Berkeley Street.



Each Division has a switchboard with the numbers of all the boxes in that Division listed, and a direct connection to Central Headquarters. The Division has an independent system of signal cables called a division circuit. Each signal box operates on a separate circuit; the total number of box circuits constitutes the division circuit. The signal system in each Division is connected directly to the Division Station House. Boxes located on division boundaries may be dual boxes, connected into two Division Stations. Dual boxes are equipped with a switch that allows selection of the desired circuit.

Police officers on a route are required to call the Station House at regular intervals and to answer all calls from the Station House when the signal light on the box indicates a call. In addition, the patrolman uses the signal box to report any emergency. All police officers have a key which is used to open the signal box before a call can be made. Keys are also made available for MTA starters and guards, bank guards and other responsible persons for use in emergencies.

The signal box circuit is a 24 volt, battery operated system. These batteries are located at the Station House of each Division.

The signal box system has been laid out on a rational basis. Boxes are located at squares, intersections, and habitual trouble spots. New or additional boxes are installed by order of the Director of Signal Service upon request from Division Captains.

The police radio system is auxiliary to the signal box system. Radio communication is possible between vehicles and police headquarters, but not



division stations. Emergency calls to police are received at headquarters, and police in cars are dispatched to the scene by radio. They report back by the signal box system. There are several reasons for this procedure, not the least of which is the fact that the Federal Communications Commission rigidly regulates the use of radio. Although the radio system itself is not pertinent to this report, its use has been discussed to emphasize that radio is not a substitute for the signal box system.

#### Back Bay CNRP Area

The Back Bay CNRP Area lies entirely within Police Division 16. Most of the police signal cable is in underground conduit owned by the New England Telephone and Telegraph Company, but where telephone conduit is not in the necessary location, the cable is in underground conduit owned and maintained by the Boston Fire Department. The complete inventory of conduit and its ownership is shown on Exhibit 47-3.

The cable used in the system is of various sizes: the smallest containing 11 pairs of conductors and the largest, 61 pairs. The cable is composed of copper conductors, individually wrapped in paper insulation, and all encased in a 1/8 inch lead shell. Paper insulated conductors are the best for voice communication. New cable was installed in the entire system in the late 1930's.

Interviews with principals of the signal service indicate that the police signal system is in good condition and is adequate in that it accomplishes the purposes for which it was designed. It is apparent from discussions that there could be significant savings in manpower and a higher



degree of communications efficiency if the present system were modified. There are, however, no plans available at present proposing modification of the existing systems.

Normal maintenance is carried on by the signal service at all times and repairs are accomplished as necessary. Budgetary restrictions limit the size of the maintenance force. This precludes a regular program for testing of the circuits.

#### CONCLUSIONS AND RECOMMENDATIONS

In summary, on the basis of available information, it appears that the police signal system is adequate to accomplish the purpose for which it was designed. The general condition of the system is good.

At such time as advanced planning is available, it is recommended that the Authority, in conjunction with the Director of Signal Service, take into consideration the feasibility of modifications to the system consonant with the objectives of the signal service and the Boston Development Program.

It should be noted that this Interim Report does not reflect any effect on the police signal service of the conclusions and/or recommendations from the recently released so-called "Quinn-Tamm Report" on the Boston Police Department.



## FIRE ALARM SYSTEM

### INTRODUCTION

The City of Boston Fire Department is under the supervision of a Fire Commissioner, Fire Chief, Deputy Chiefs and District Chiefs. The fire alarm system in Boston is administered by the Fire Alarm Division of the Fire Department under the general supervision of Fire Commissioner Thomas J. Griffin, with Albert L. O'Donion, Superintendent in direct charge. Mr. Earl F. Lyons is Assistant Superintendent and is in charge of construction and maintenance for the system.

The first electrically operated fire alarm system in existence was put into service in Boston on April 20, 1852, covering South Boston and the city proper as it existed at that time. Subsequently, alarm systems were put into service or added to the Boston system in East Boston in 1864, Roxbury in 1863, Dorchester in 1870, and Charlestown, West Roxbury, and Brighton in 1874. The last significant addition to the fire alarm system came in 1912 when the Town of Hyde Park, including its alarm system, was annexed by Boston.

The National Board of Fire Underwriters in their "Standard for the Installation, Maintenance and Use of Municipal Fire Alarm Systems" (NEFU No. 73) describes a municipal fire alarm system as "...an electrically operated means of notifying a fire department that a fire has occurred." The Standard further describes a complete municipal fire alarm system as one that "...fulfills two functions, that of receiving alarms from the public through fire alarm boxes located on the street and that of transmitting



The alarm to these fire companies which must respond to the emergency. Municipal fire alarm systems also have facilities for receiving alarms from persons using telephones, and facilities for informing other interested parties, such as the police department, health department, hospitals, and others of an existing fire or emergency.

A fire alarm system is an essential element in the fire defenses of a city. Any system regardless of type, must have the prime requisites of accessibility, speed of transmission and reliability. It is of interest to note that the National Board of Fire Underwriters in their Grading Schedule based on many years of study with reference to the fire defenses and physical conditions of a municipality, considers the relative value of a Fire Alarm System to be 11 out of a possible 100 percent.

#### EXISTING SYSTEM:

##### General

The present Boston Fire Alarm System is a Type A (Manual Retransmission) system, with the exception of Long Island which, due to inaccessability, is a Type B (Automatic Retransmission) system. The Type A system requires an operator at the Fire Alarm Headquarters to check the receipt of alarms and to retransmit all alarms to fire stations and, if used, to outside sounding devices. The Type B system is "automatic" as implied.



Boyle's Type A system, sometimes called the "Morse" system, was placed in service in 1923 with modifications to the system made in 1934. The receiving and transmitting apparatus, including the battery-power source, is located in Fire Alarm Headquarters at 59 Fenway, opposite Oakland Avenue. The building was constructed in 1924, especially for this purpose.

All fire alarm boxes are connected to Fire Alarm Headquarters through wire circuits. There are 94 box circuits with approximately 20-25 boxes on each circuit. The circuits, normally closed, open when a box is pulled and a signal is received at Fire Alarm Headquarters. Operators at Headquarters, after receiving the signal from the box circuit, transmit the alarm to all interested parties through so-called alarm circuits. Alarm circuits are divided into three categories: primary, secondary, and local, each of which has its own power source. The primary system consists of 19 circuits connecting Headquarters to the fire houses, plus two local circuits at Headquarters making a total of 21 primary circuits. The secondary system consists of 16 circuits connecting Headquarters with fire houses and police stations. The ten or more local circuits are mostly for operating registers, time stamps, and other instruments at Headquarters. In addition, from Headquarters there are 9 mutual aid circuits connecting to fire department headquarters in the adjacent cities and towns, one circuit connecting to the High Pressure Fire Service pumping stations, one circuit connecting to the City Hospital, one circuit connecting to the Sumner and Callahan Tunnels and circuits connecting to the City Water Department and City Hall.



In part, cables, private or auxiliary, connected to buildings, summer schools, office buildings, etc., are not the responsibility of the Fire Alarm Division of the Boston Fire Department. These private or auxiliary cables and boxes are installed, maintained, and tested by others.

There are two private companies which receive alarms transmitted at Fire Alarm Headquarters - Boston Automatic Fire Alarm Company and American Electric Telegraph Company. These companies install and maintain their own circuits and provide power for operation. Their circuits are installed in conduit leased from the telephone company and are connected through a relay to a fire house in the vicinity of their own offices.

The Fire Patrol is an insurance company-supported organization that receives alarms from Fire Alarm Headquarters through primary and secondary circuits. The circuits are owned and maintained by the Fire Department; however, the receiving instruments are not supplied by the Fire Department.

#### Interviews and Remarks

Interviews with principals of the Fire Alarm Division indicate that, within the present budget restrictions, the existing fire alarm system is considered to be entirely adequate. It is apparent from discussions and a review of the "Report to the City of Boston by the National Board of Fire Underwriters" of May 1951, that the present system could be improved were additional funds available; however, no major changes in the system are in process or are contemplated.

Conclusions in the NDFU Report indicate that the "system is of proper type and has sufficient provisions for future growth," and that "...part of the cables are in only fair condition."



### Fire Alarm Cable

Fire alarm cable is placed in an array of underground positions. Most of the underground cable is located in the main supply conduit. However, the Boston Fire Department uses the cable within the conduits and underground conduit in important fire utility facilities and not available. The complete inventory of conduit and its ownership is shown on Exhibit 47-3.

Fire alarm cable is of two types, lead encased and polyvinyl-chloride encased. The cables vary in size from 4 conductor to 91 conductor. In general, all cable placed in the past fifteen years is polyethylene insulated, polyvinyl-chloride encased; prior to that, lead encased cable was used exclusively. The average life or expectancy of the lead type is about fifty years, but the polyvinyl-chloride type can be expected to last at least eighty years. However, cable life is affected by local conditions, and only testing or inspection can determine its condition.

The condition of the cables in the conduits can be checked by taking electrical resistance readings and by other methods; however, because of the expense involved, the Division usually depends on visual inspection and replaces cables only when they ground out or otherwise fail. Grounded circuits can be detected from headquarters by observation of voltage. Normal testing, repairs, and maintenance of the system are required and are carried on constantly.











hundreds of the transportation system. The development and physical layout of the system involves, essentially, the use of a system of tunnels and elevated structures in areas of greatest congestion and the use of surface trackage in the more suburban, outlying, areas of coverage. An extensive system of bus routes complements the electrically powered portion of the system.

Electrical power for operating the transportation system is produced at two power stations: Lincoln Power Station, located on Lincoln Wharf, near Commercial Street, in the North End of Boston, and the South Boston Power Station, located on "O" Street, near East-First Street in South Boston. The power produced at these stations is transmitted via underground cables as alternating current (13,200 volts, 95 cycles) to 25 substations which rectify this power and distribute it as direct current (600 volts) through a system of underground conduits. All rapid transit trains, trolley cars, and trackless trolleys are operated from direct current.

The MTA owns and maintains for its exclusive use all cable, conduit, ducts, and manholes. The Boston Edison Company and the MTA have a "tie-in" arrangement to permit power transfers to aid one another during peak hours and in case of emergency.

The "Report of the Joint Special Legislative Committee on Transportation," dated January 30, 1962, indicates that a serious power generating problem exists within the Metropolitan Transit Authority. The Boston Edison Company has submitted to the MTA a proposal for the purchase of the power plants and for the sale of power to the Metropolitan Transit Authority. Engineering



















## APPENDIX A

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1215	1913	1050	1929	2151	1949
1635	1915	1278	1942	1600	1936
56	1930	187	1937	3400	1962



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